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OCTOBER 5, 1976

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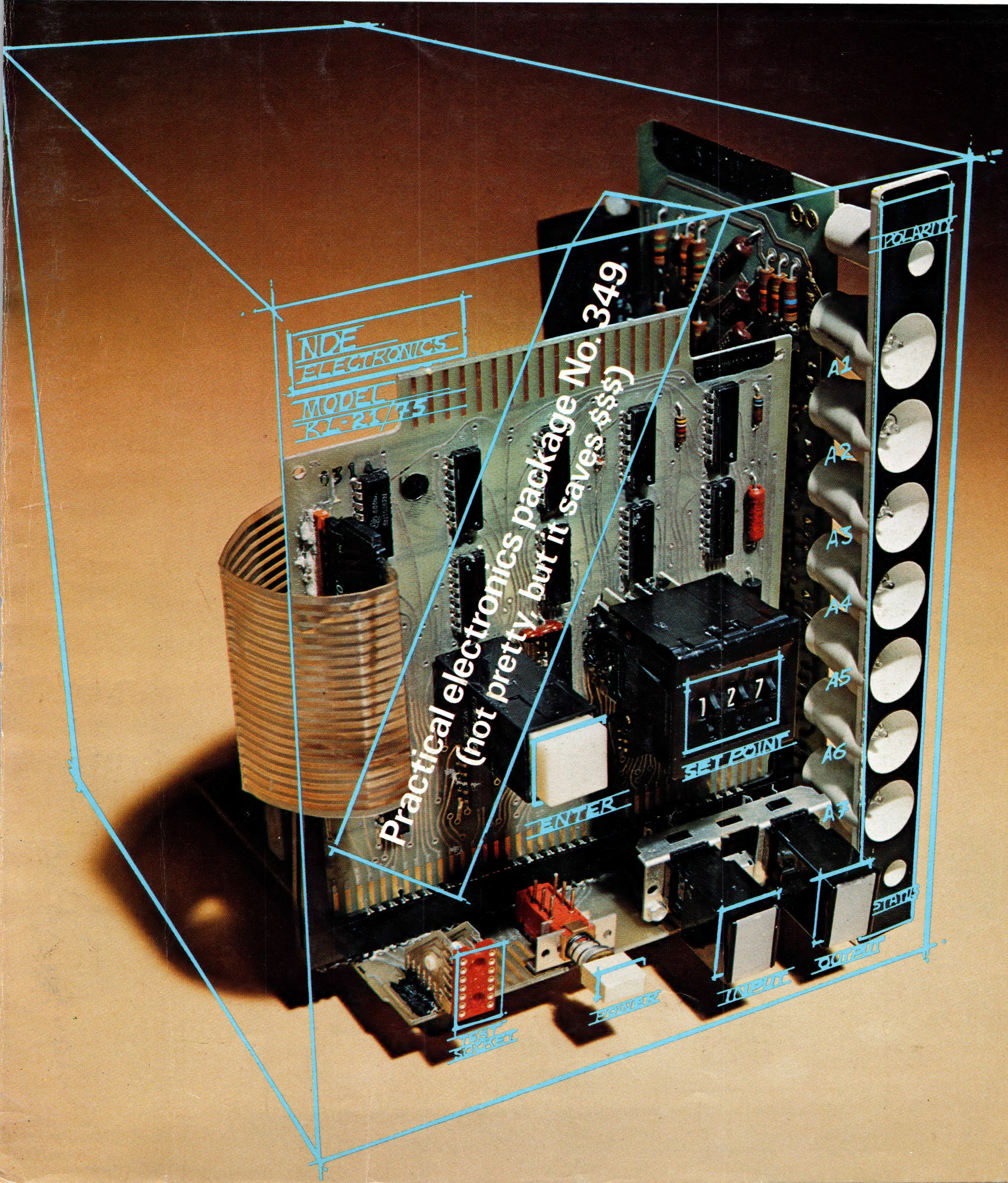
EDN

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

Add vectored interrupts and memory mapping to 4-bit μP's

Use software building blocks to simulate analog circuits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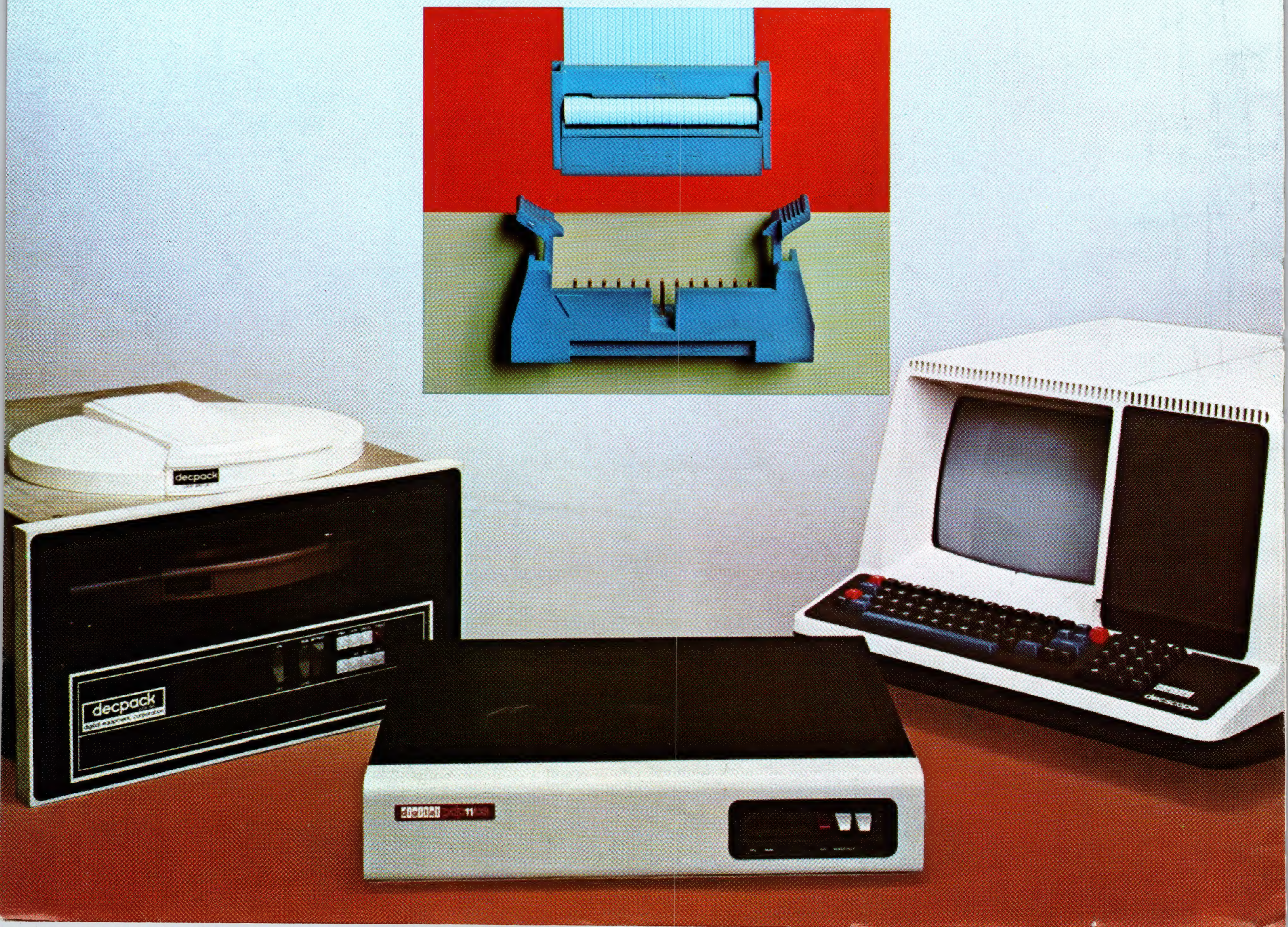

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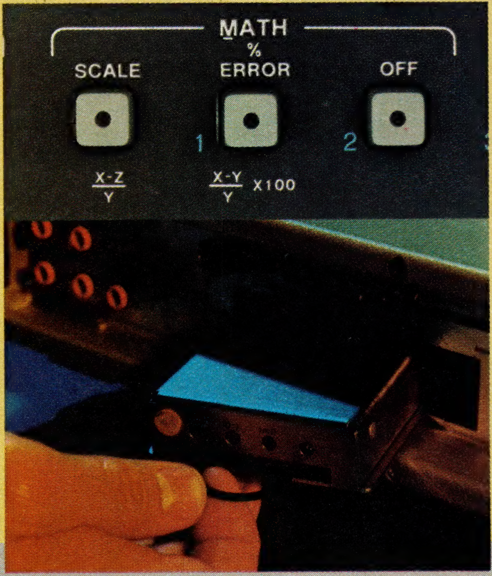

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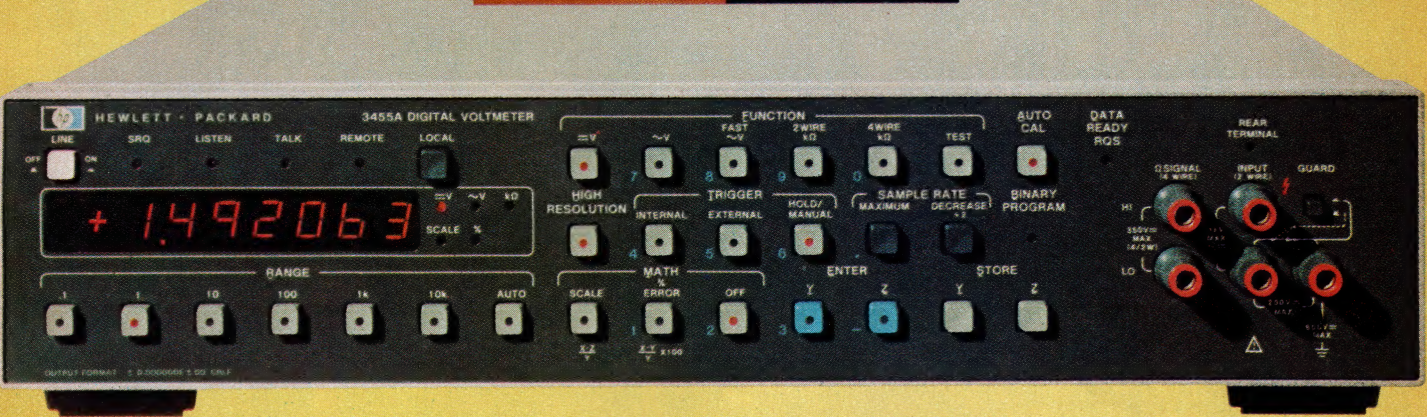

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OCTOBER 5, 1976
VOLUME 21, NUMBER 18

EDN

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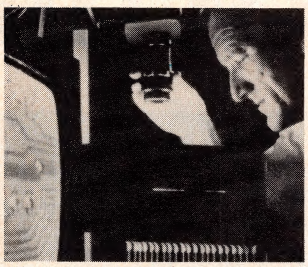
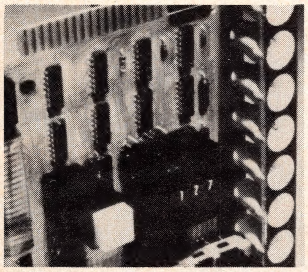


PC-board tester . . . pg. 23



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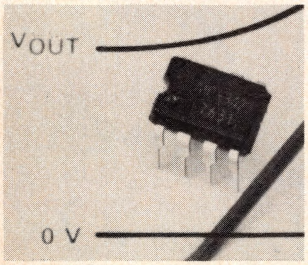

Overvoltage IC . . . pg. 112

DESIGN NEWS

Sometimes, not seeing the light saves time and money 23
Ambient light furnishes power to charge digital watch's batteries . . . Exposition will spotlight electric vehicles of all types and sizes . . . A computer in every home? Thanks to the μC-hobbyist boom, it's coming a lot faster than you might imagine!

μP APPLICATION IDEAS 33
Programmed dicing saw slices wafers easily and precisely with μP's help . . . μP replaces cam controller in environmental test chamber, adding simplicity plus accuracy.

DESIGN FEATURES

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The zero-mass approach shows the clever EE how to design using fewer components while making them do more work!

Add vectored interrupts and memory-mapped I/O to 4-bit μP's 55
Has the somewhat limited I/O structure of 4-bit μP's constrained your designs? These "memory-expanding" schemes just might help.

This 30-ppm scale proves that analog designs aren't dead 61
Electronics does not live by μP's alone. This analog instrument achieves 0.02% absolute accuracy, yet never needs adjustment.

Simulate analog circuits with digital-filtering circuits 93
These equations let users breadboard virtually any circuit that can be built in hardware with equivalent software.

Microprocessor programming — which language is best? 101
Too often we assume that assembly language and a higher level language are incompatible. Perhaps some rethinking will pay off.

DESIGN AWARDS 104
This PLL lock indicator uses a single IC . . . Line driver is compatible with OCI line receiver . . . Divide-by-N uses shift register . . . Build a function generator with a 555 timer . . . Binary to BCD conversion with μP's.

PROGRESS IN PRODUCTS

Overvoltage-protection IC will always "let you down" 112
Matrix LED display packs more electronics to significantly reduce system parts count.

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COVER

As this mock-up shows, a pretty enclosure can hide functional but not-so-attractive internals. Our thanks to Phil Brooks who provided this unit to demonstrate some of the packaging techniques mentioned in this 3-part series; Part 1 begins on pg. 46.

BPA ☆ABP

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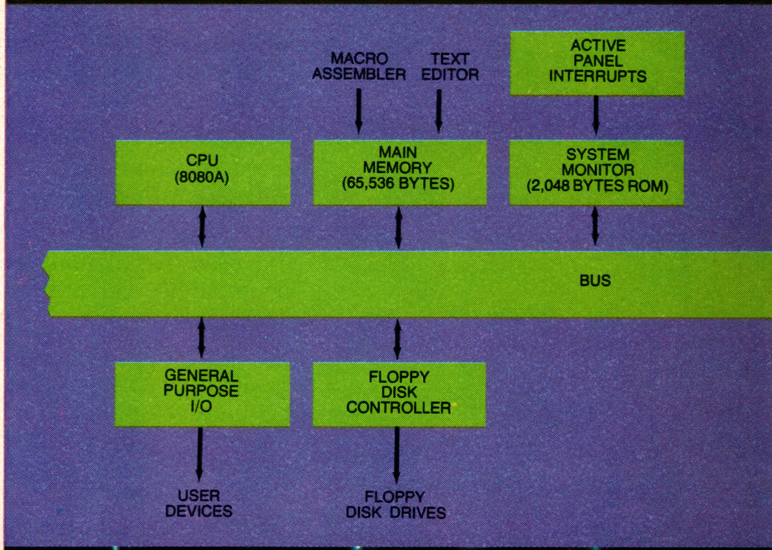
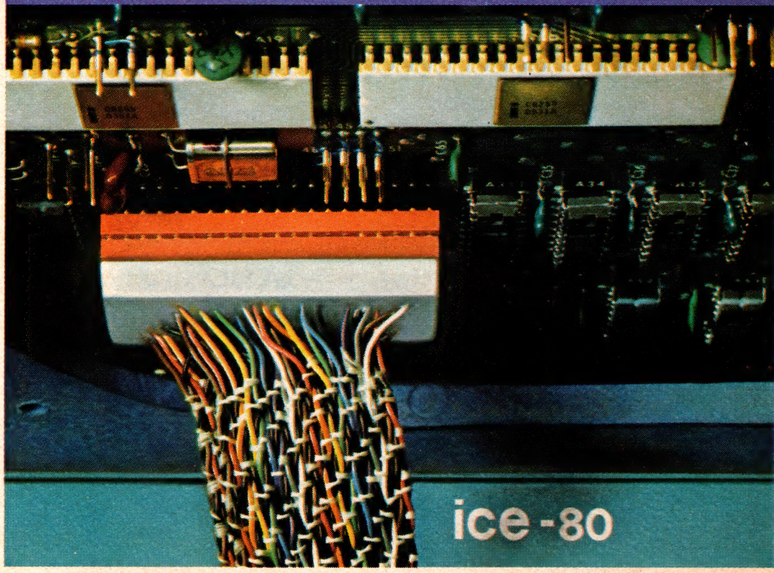
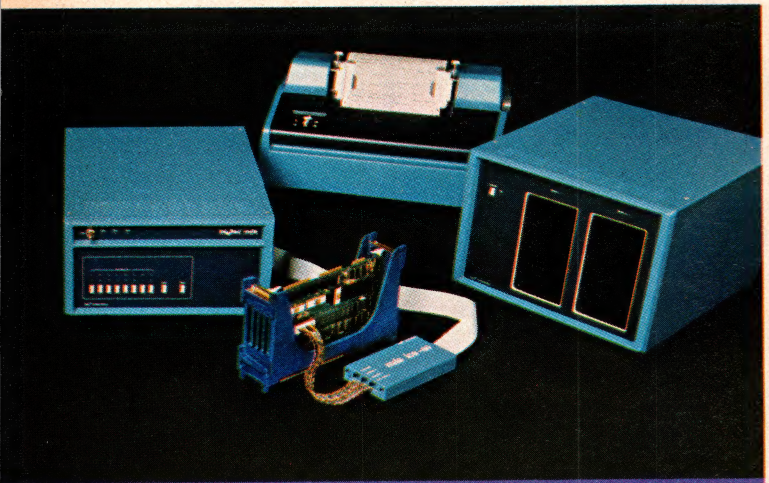
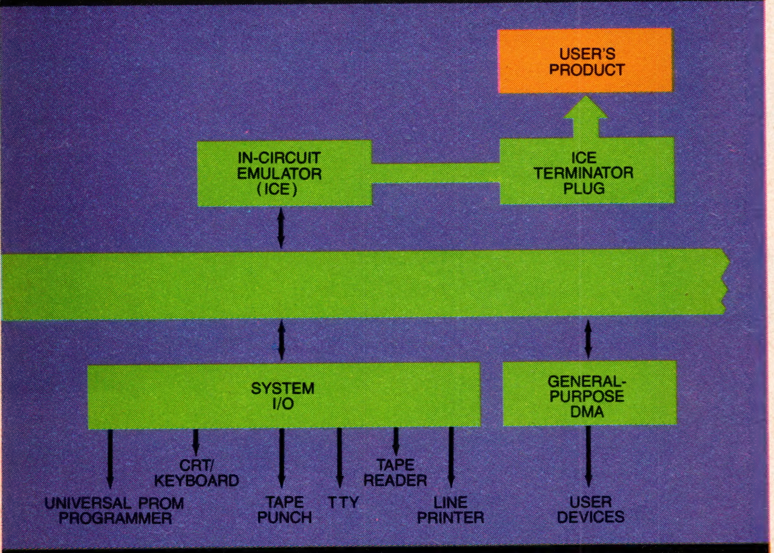
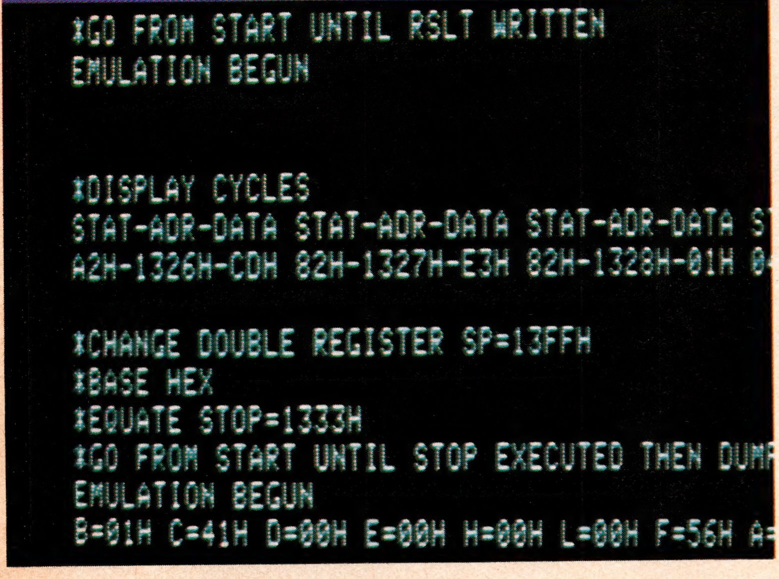




lets you see what your it's still on the bench.







```
*GO FROM START UNTIL RSLT WRITTEN
EMULATION BEGUN


*DISPLAY CYCLES
STAT-ADR-DATA STAT-ADR-DATA STAT-ADR-DATA
A2H-1326H-CDH 82H-1327H-E3H 82H-1328H-01H

*CHANGE DOUBLE REGISTER SP=13FFH
*BASE HEX
*EQUATE STOP=1333H
*GO FROM START UNTIL STOP EXECUTED THEN DUM
EMULATION BEGUN
B=01H C=41H D=00H E=00H H=00H L=00H F=56H A
```

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BI-FET

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So, to our original Amen we can only add, Amen.

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16K Core Memory, expandable to 64K.

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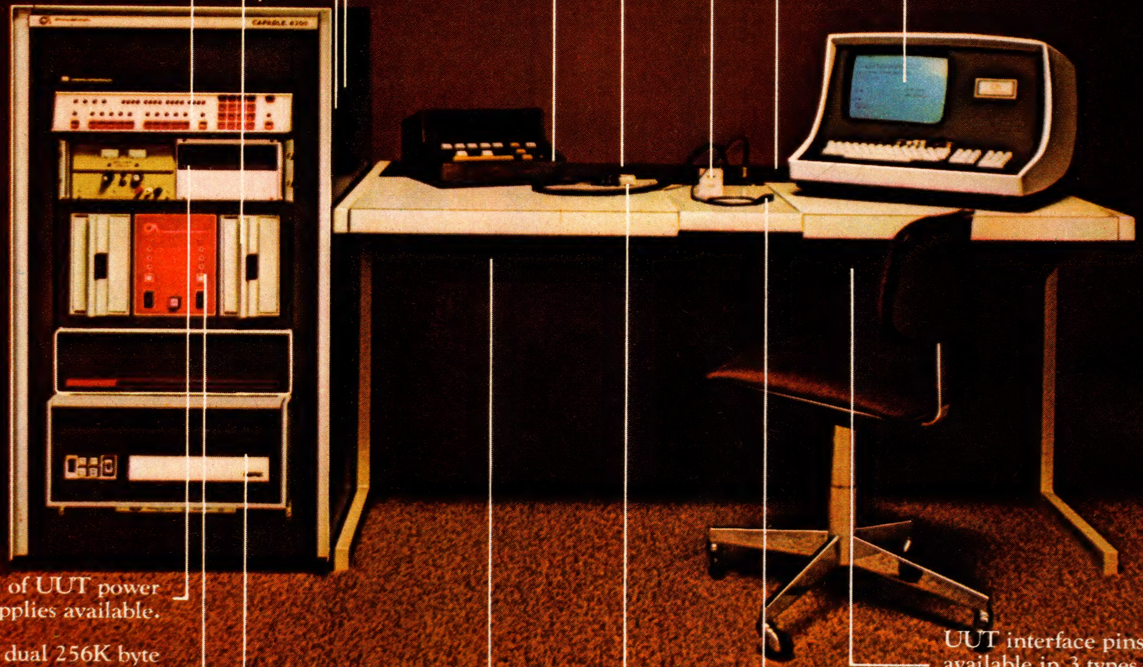

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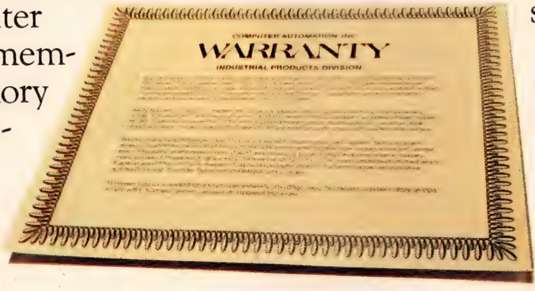
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Next, there's Guided Fault Isolation (GFI) with both a single point probe and our new Clever Clip,™ which can handle IC's up to 24 pins. This not only makes testing faster, but also minimizes the chance for error because the operator has less to do. There's even a special readout that tells you if the clip isn't making proper contact with the pins.

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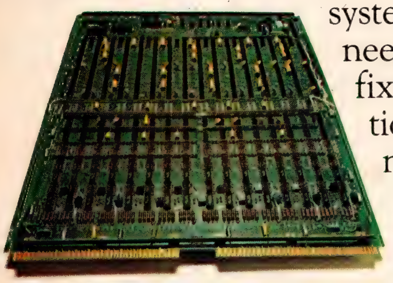
CAPABLE testers are available with three types of pin electronics—TTL, CMOS, and programmable. So we can tailor a test system to your specific needs and minimize fixturing and adaptation costs when your needs change.



And since our entire system is modular, you can add pin electronics up to 767 pins as your boards become larger and more complex. You can add additional memory as your test routines become larger. You can add new logic families. Or you can convert your CAPABLE into a complete analog test system. All as you need it.

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The list of CAPABLE features goes o Automatic Test Generation (ATG). Fault Detect Verification (FDV). Analog testing capability. A ticket printer for producing hard copy failure reports. Even an alphanumeric CRT input/output terminal with standard office typewriter keyboard

And CAPABLE testers carry the most complete support program available. Starting with a one-year, on-site warranty on the entire system—no exceptions. And including one week of technical training at start-up and on-going engineering assistance as you need it.

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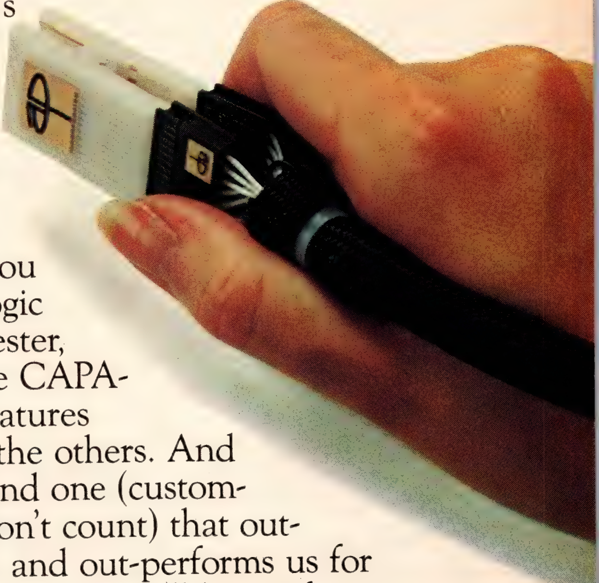

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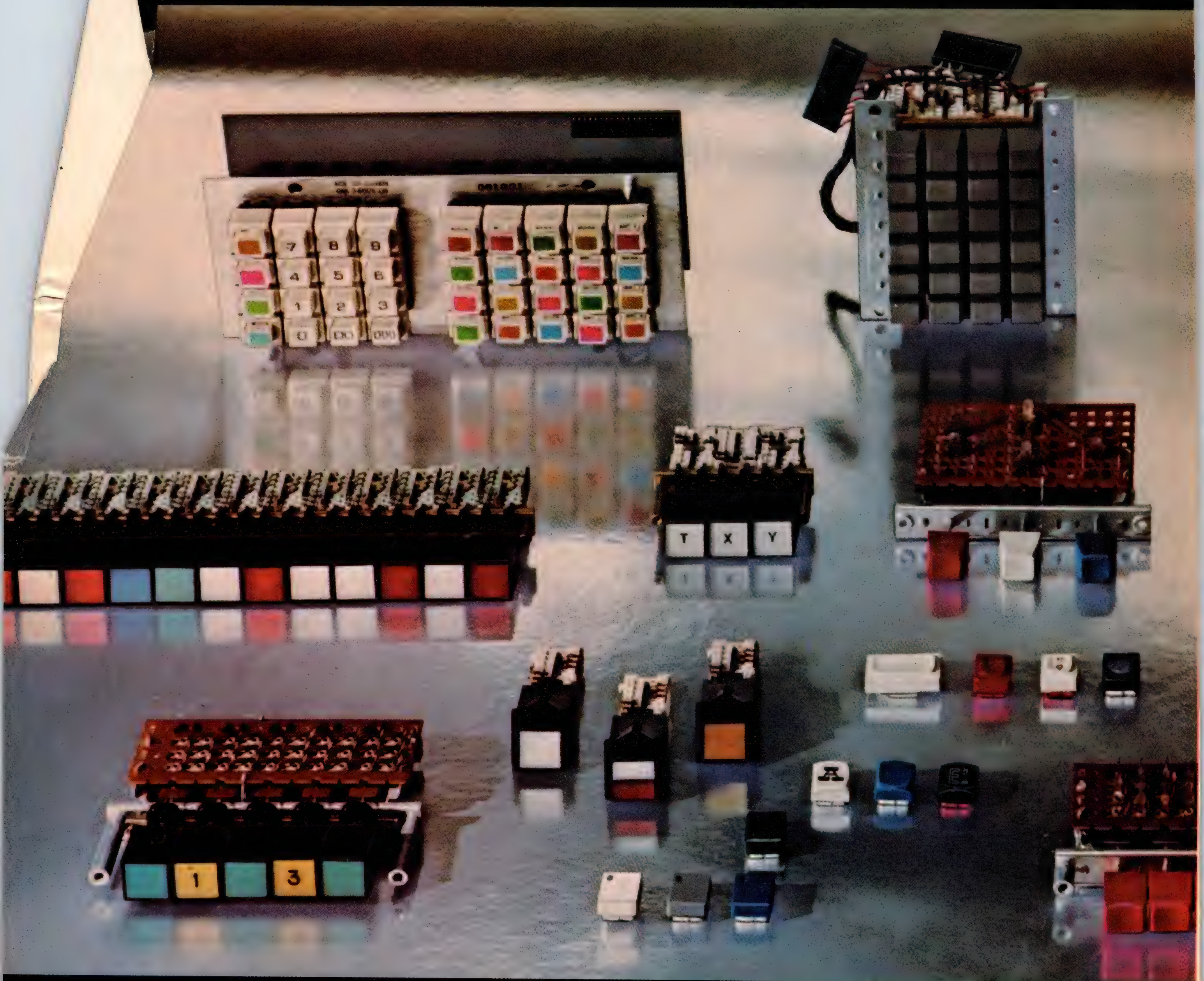


It isn't just the wide range of switches. It's what Oak will do with them—for you—that should make Oak your preferred supplier.

You can get switch assemblies mounted on a custom PC board or metal bracket, or completely wired with cables, harnesses and connectors, including stamped or machined parts ready for installation in your equipment. And it's all done in-house on Oak production equipment and assembly lines.

Of course, we can supply all of your simpler requirements as well, including an almost unlimited selection of switching configurations, cap legends, styles and colors for lighted or unlighted switches.

Contact your Oak sales offices, distributors or call for price and delivery information.

1. Data input keyboard for financial systems. Series 400 switches with aluminum panel and PC board. Special removable caps permit rapid legend changes for reprogramming.

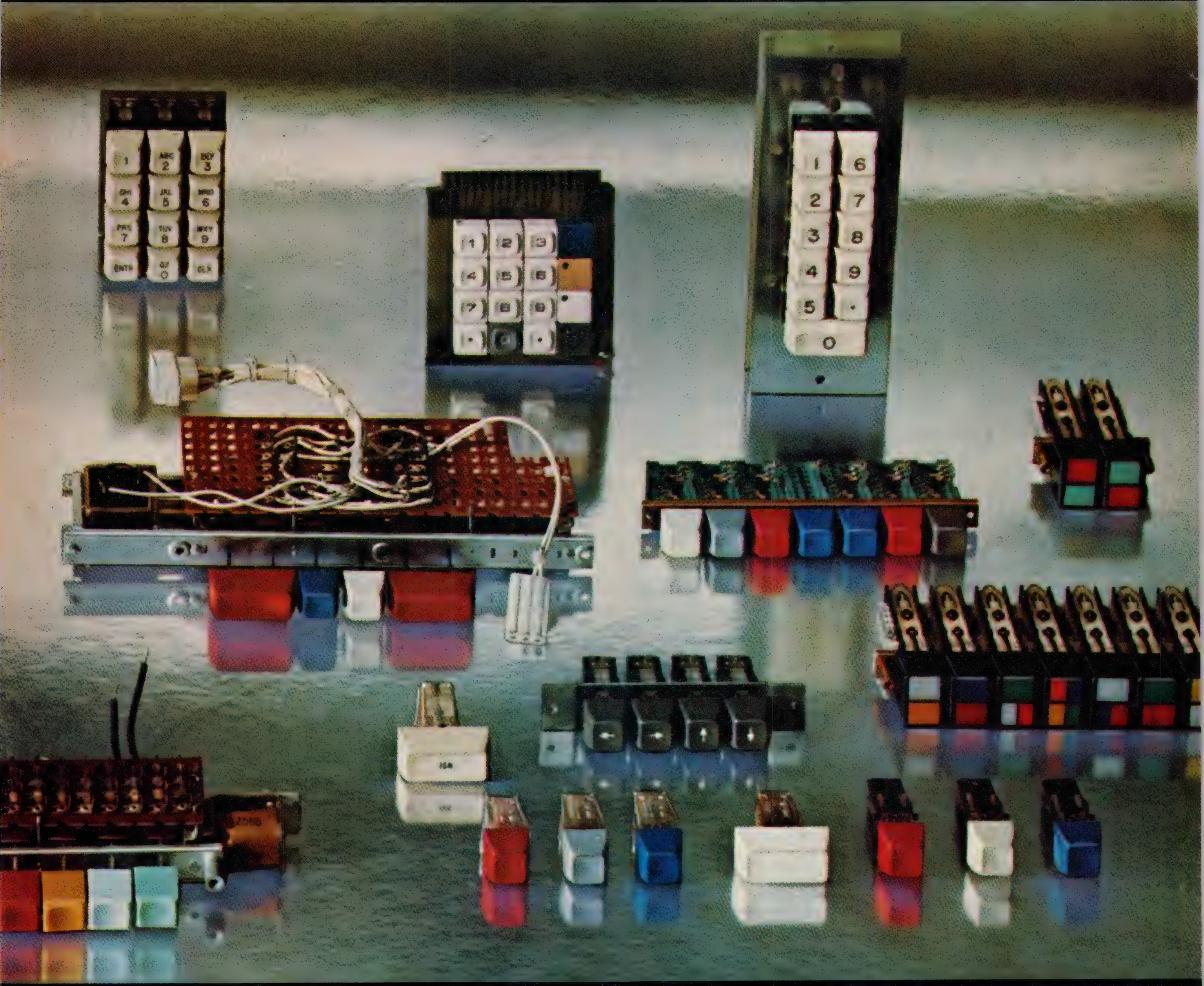
2. Banking terminal input device using Series 300 switches. Completely wired with harness and connectors.

3. Data input using Series 475 switches, flow soldered to customer's PC board.

4. Series 415 and 415 Light Emitting Diode Switches on PC board, with discrete components attached on back.

5. Program selector keyboard of Series 475 switches assembled with aluminum panel and printed circuit boards used for coin operated equipment.

line of push-button and keyboard switches



6. Series 300 switches, single and ganged, lighted and unlighted, can be supplied completely wired.

7. Series 130 switch, for rugged applications where more switching capability is required. Terminal board is integral part of switch assembly.

8. Microwave oven switch assembly with quick-disconnect terminals using Series 130.

9. Facsimile transmission assembly with special mounting bracket, wiring, cable and connector, and solenoid for clearing all Series 130 switches.

10. Unlighted Series 300 switches can be supplied in almost any inconceivable switching combination of alternate, momentary, interlock and lockout.

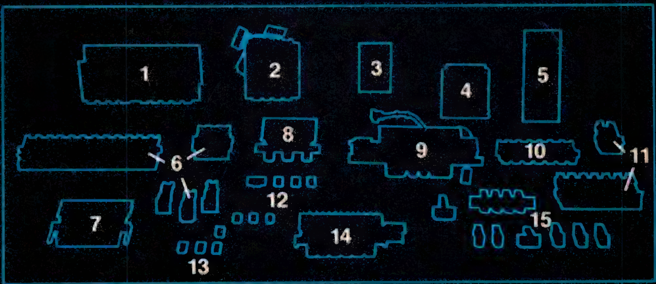
11. Bank security code system uses 4-lamp, 4-display Series 300 switches. As many as 12 switches can be prewired, to customer specifications, in a single bank.

12. Very low profile, low cost Series 415 switches are available in five different button styles in a wide range of colors.

13. Series 415 switches with LEDs, on a separate circuit, vastly improve error-free operator performance of data input devices.

14. Microwave oven assembly with solenoid for latching release, partially wired to customer requirements.

15. Series 400 and 475 keyboard switches can be supplied assembled in Oak produced brackets, or individually, with or without snap-in mountings.



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What's the right price for this 1 Form A dry reed relay?

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Would it help if we told you it's available in both Form 1A and 2A with .1″ and .15″ pin spacing, is the most automatically manufactured dry reed relay in the whole world and is available from stock ...from Wabash? The right price? All the prices are right. They're the under 25, 100 or MORE and 25,000 prices respectively.

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For more information, Circle No. 12

SIGNALS and NOISE

Further adventures of the HP-45 crystal clock

When EDN ran the last of three columns (February 20, April 20 and May 20) on turning an HP-45 calculator into a stopwatch, we thought we'd laid the matter to rest. However, the volume of mail that came in with questions, suggestions (some anonymously) and just plain trials and tribulations from owners convinced us we were wrong. So here is the latest scoop.

The modifications shown in our May 20 "Signals and Noise" column will work on most HP-45's. However, it seems HP produced two calculator versions—undistinguishable unless you open them up. Thus, if your previous modifications do not work, try connecting the crystal lead to the opposite side of C_2. We also note that L, C_1 and C_2 are installed HP parts. You only add the crystal and possibly R_1 to eliminate start-up problems.

Apparently one of the biggest problems is getting the proper crystal. HP has informed us directly that the part is not for sale. Anyone who managed to acquire a crystal did so because of a glitch in the service-parts ordering system (now corrected). They also stated that modifications to any HP calculator will void the warranty.

But for those intrepid tinkerers who are still game, all is not lost. Egbert Electronics, 876 East 900 North, Apt. 15, Provo, UT 84601, has a supply of the proper crystals available for $12 plus $1 shipping.

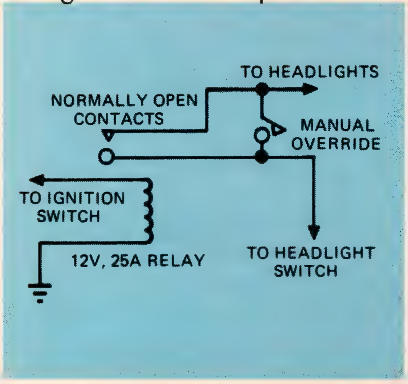
If you've already modified your calculator, you now have more than a stopwatch. One reader uses his as a regular watch. All you do is enter the time (up to 12.59); press RCL; press CHS, 7 and 8 simultaneously; then press CHS again to start it running. Another reader mentions that the keys from 0 to 9,., EEX and CLX all serve unique functions in the clock mode. Unfortunately, he neglected to mention what these are. If anyone knows, please drop us a line.

And so goes the saga of the HP-45 calculator/stopwatch/regular watch/? Until next time, CLR.

The buzz goes on

Gentlemen:

In past issues, I have seen many circuits providing a warning signal in cars when the headlights are left on after the ignition has been turned off. Being one who hates the sound of buzzers (especially at the frequency automotive manufacturers seem to choose), I suggest the following simple circuit which does not alert the driver that he has left the lights on; it instead prevents him from doing so in the first place.



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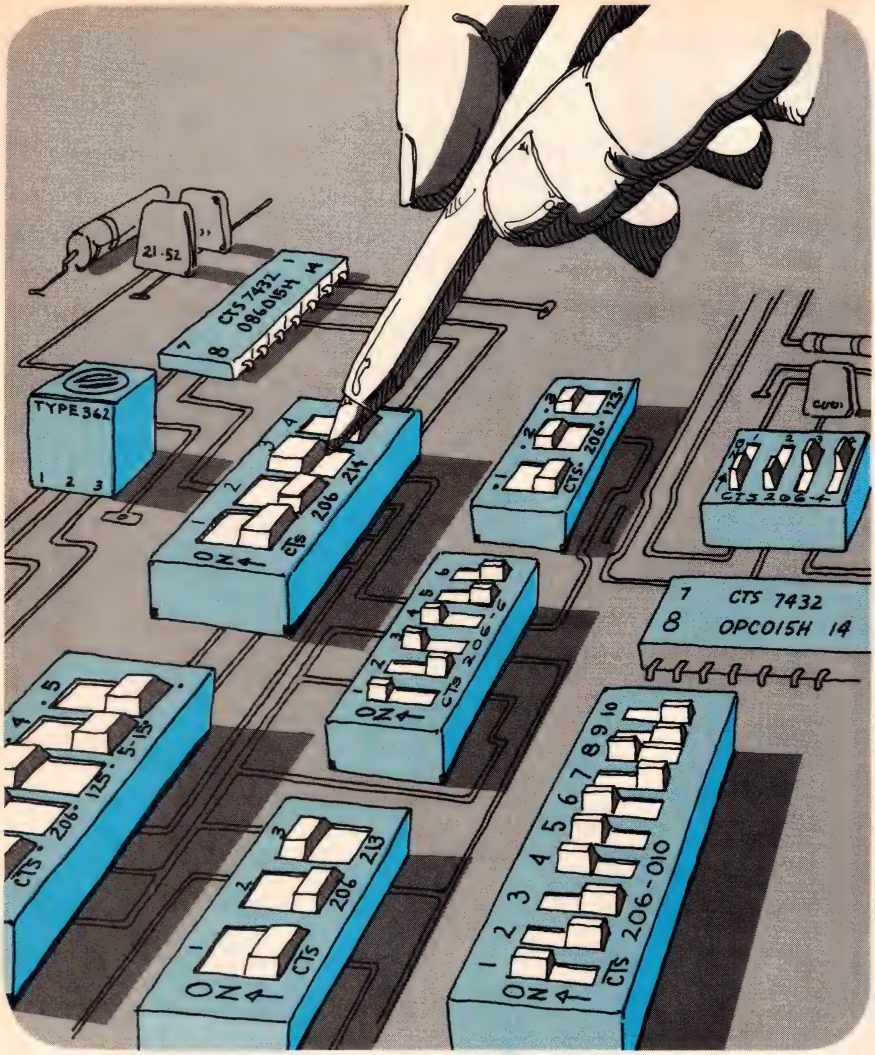

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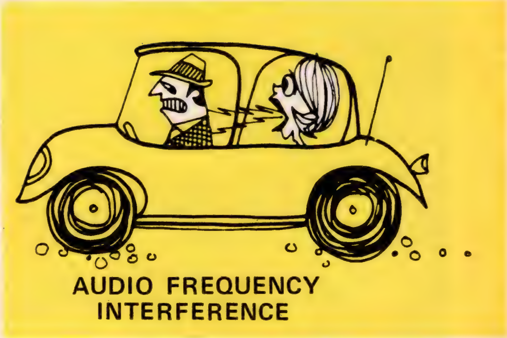
SIGNALS and NOISE

When the ignition switch is on, the normally open contacts of the relay are closed. Turning the headlight switch on will complete the circuit to the headlights. When the ignition switch is off, however, the relay contacts are open, and the headlights are off, regardless of the position of the headlight switch. In case of relay failure, a manual override switch may be inserted across the relay.

Yours truly,
Henry Bergen, Engineer
Cox and Co.
New York, NY



Ed. Note: This is one of 58 cartoons form "A Visual Aid To Electronics," by Barry L. Cole and Dick Trimarco.

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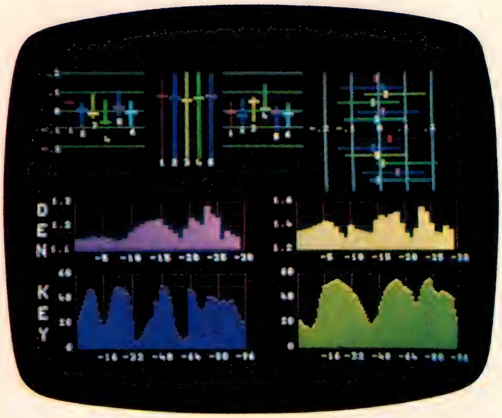
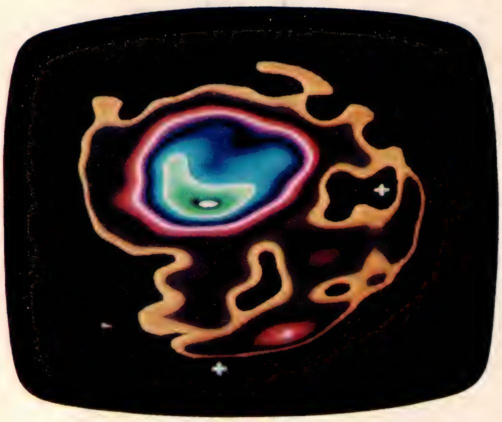


Process Control: Color printing press.



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To fully appreciate the RM9000's capability, you need more details. Call or write Ramtek Corporation, 585 N. Mary Ave., Sunnyvale, CA 94086. (408) 735-8400.

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For more information, Circle No. 15

EDITORIAL

Standardization: without it, we all lose

The standardization of form factors, specification definitions and minimum performance levels rightfully concern every designer. Yet in the marketing world a myopic mania exists: It seems as though every company wants to set de facto standards.

Typically the scenario goes like this: Company A, being the first to offer a particular type of product, seeks to capture the lion's share of the business. It also aims at setting a "standard" by virtue of wide industry acceptance of its approach. Shortly thereafter, company B develops an improved product. However, because B also wants to set the standard, it gives its version a different form factor. Or it "plays" with the specs to make its unit seem better than it actually is. Or...

As time goes on, other manufacturers join the battle, introducing products that are basically similar, but not quite the same. All companies steadfastly refuse to participate in any discussions of standardization, of course. Only after the market shake-out does any degree of standardization occur, and de facto standards are produced mainly as the result of second-sourcing agreements.

Such situations have occurred many times in the past. Examples include CMOS logic, the 4k RAM and DPM's. Yet in every instance, the lack of standardization hurts everyone: Designers lose because they can't apply the best products to new designs for fear of making a nonviable selection; marketing people lose because designer caution artificially depresses sales; and the entire industry loses because its products are not as competitive in the world market as they otherwise might be.

EDN thinks that manufacturers should take a more mature attitude toward standardization. Heartened by recent meetings among IC makers aimed at standardizing some 16k RAM parameters, we encourage marketers to organize similar cross-industry conferences in all areas where standards make sense to the user.

Meanwhile, designers can speed up the process by voicing their difficulties loud and often. EDN will make space available in our "Signals and Noise" column for concerned individuals who want to make positive contributions in this area.

Walt Patstone

Walt Patstone
Editor

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SIMPLICITY OF USE -

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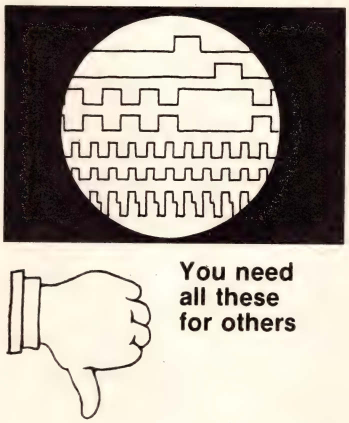

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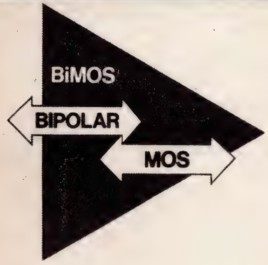
RCA BiMOS op amps. They mix technologies to match circuit needs.



BiMOS was born with our CA3100. On a single chip we combined Bipolar with PMOS—for a more cost-effective wide-bandwidth op amp.

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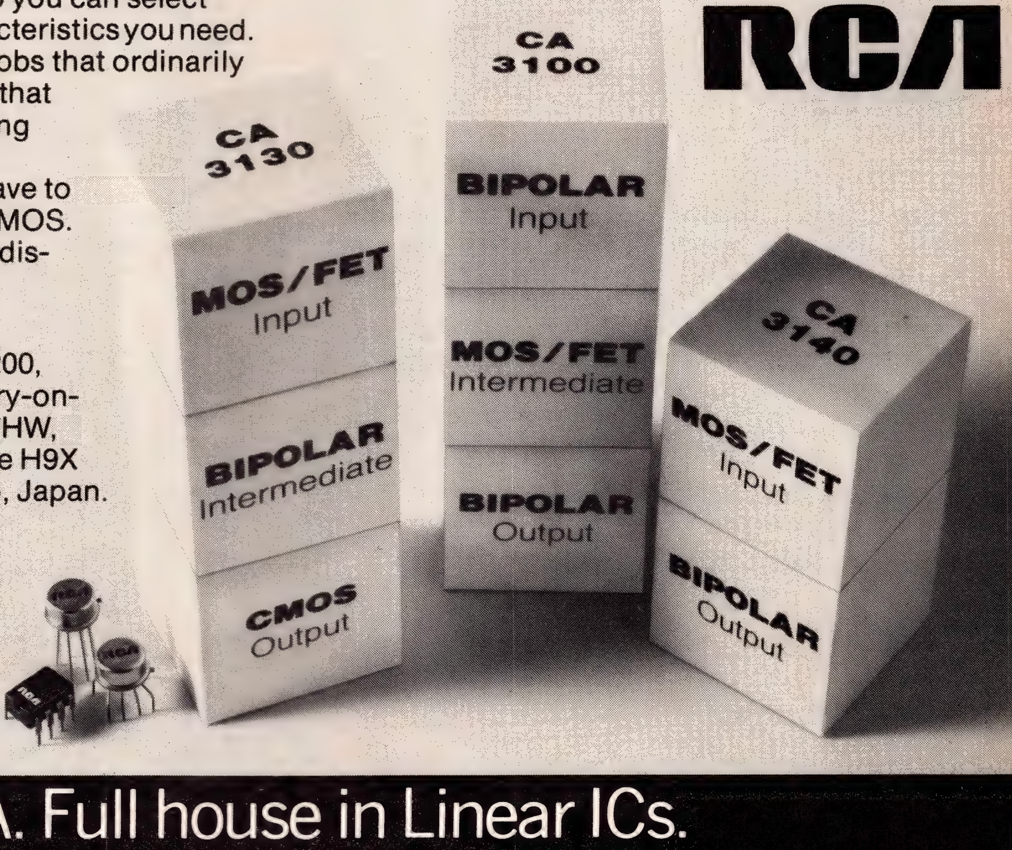
3L3, Canada; Fuji Bldg., Tokyo, Japan.

Op amp category	What BiMOS contributes	RCA device
General Purpose	Wide applicability. Low cost.	CA3140 CA3130
FET Input	Lower device cost. Reduced circuit cost. Large input voltage range: capability of swinging to 0.5 V below rail.	CA3140 CA3130
Wideband 4.5 to 70 MHz	High slew rate with low ringing.	CA3140 CA3130 CA3100
Micropower down to 1.5 mW	Strobability.	CA3130
High Current up to 22mA	Eliminates driver stage. Low device cost. Rail-to-rail output swing.	CA3130

RCA



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That's the way it's been at Motorola since we put our CMOS technology in gear, that's the way it is now, and that's the way we intend to keep it. By doing what you want, we get what we want.

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You'd naturally expect that kind of precision to cost a bundle, so maybe the best part of the Super One-Shot is actually the $1.76 price.

Join the swelling ranks of Super One-Shot users today.

For information circle 25.

ANALOG SWITCHES? PICK THE HOT ONES

Our Austin, Texas "Silicon Ranch" is popping out great volumes of analog switches, and we've lined up some hot ones. The MC14066B quad analog switch/quad multiplexer is now generally preferred to the older MC14016 because it has significantly lower ON resistance at higher voltages. Try it at $.70. MC14051B, 14052B, and 14053B are, respectively, 8-channel, dual 4-channel, triple 2-channel analog multiplexer/demultiplexers. All three pin-for-pin replacements for the CD4051B, 4052B, 4053B can control analog signals over the full supply voltage range, and each is priced at $1.15.

For information circle 26.

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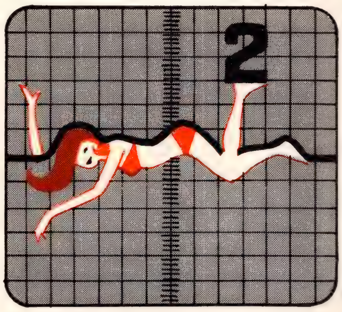
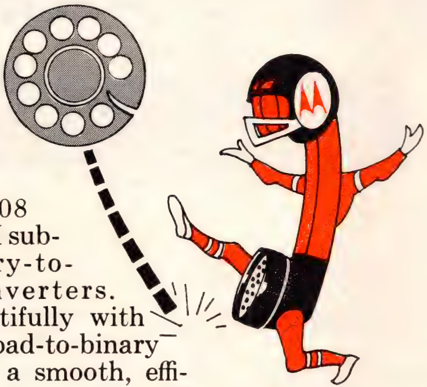


NOW THE PRICE IS RIGHT.

Now it's practical to upgrade gate performance with Schmitt Triggers. The MC14584B Hex Schmitt Trigger and MC14093B Quad 2-Input "NAND" Schmitt Trigger eliminate race problems associated with gate and inverter functions like the MC14011 and MC14069 by squaring up slow changing waveforms. There's no need to change PC boards; they're direct plug-in replacements. Noise immunity also is superior. The kicker is price, and you never saw CMOS Schmitt Trigger prices like these. Each is $.54.

For information circle 27.

HELLO BUTTONS – GOODBYE DIALS



Both the MC14408 and MC14409 MSI subsystems are binary-to-phone pulse converters. Either pairs beautifully with the MC14419 keypad-to-binary code converter in a smooth, efficient, cost effective keypad pulse dialing system with the last number stored for one-push redialing. Add more memory and a little circuitry and it remembers more numbers. No tones required, just push the buttons and get controlled dial pulses. That's Motorola innovation in CMOS LSI. The 408 and 409 are each $6.98. The keypad encoder is just $2.25.

For information circle 28.

HAPPINESS IS A PLL APPLICATION FOR THE MC14568B

Can a CMOS MSI Phase Comparator with Programmable Counters find happiness in PLL applications? Judge for yourself. The MC14568B is barely introduced, yet more than a million units are already sold into PLL bliss. Programmable divide-by-N counters like the MC14522B and 14526B extend its counting range and coming soon is a dual BCD/binary counter (MC14569B), specially designed for operation with the 14568B. The plastic MC14568B is an MSI bargain at $2.61.

For information circle 29.

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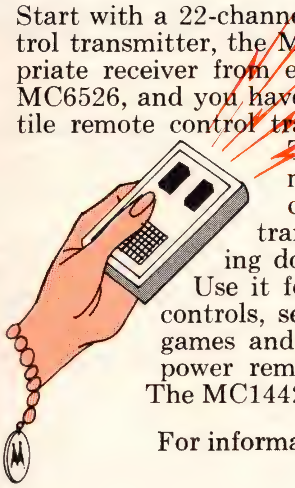

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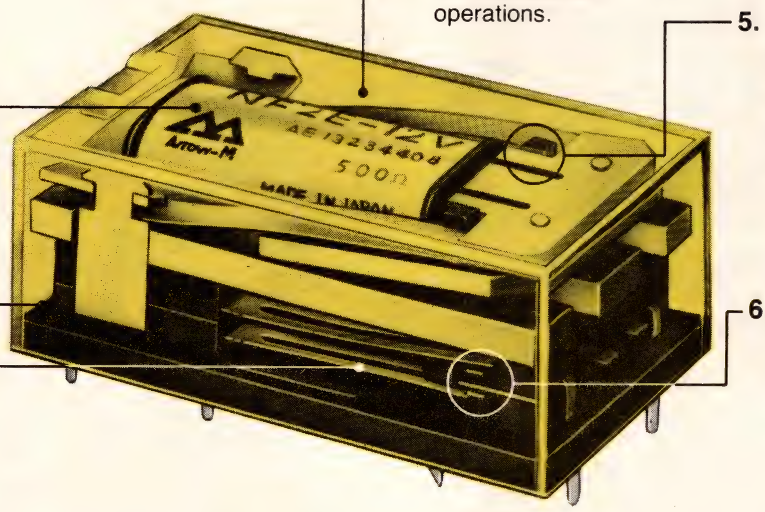
Bifurcated gold clad lift off contacts. Applicable to low level circuits.



Sound advice for the alarm industry.

You know better components make a better alarm system. So it pays to install the most reliable relays available today: Arrow-M NFE Amber Relays . . . supported by our unique and advanced manufacturing techniques. They offer you:

Reliability — The secret is a unique automated modular assembly coupled with lift off bifurcated contacts and a rebound absorbing mechanism. Installed in a sensitive alarm, it can go unused for long periods of time and still work when needed.

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The proven dependability and sensitivity of Arrow-M Amber Relays is based on more than 50 years of meeting the advancing needs of modern technology. So for relays that make it easier to make a better alarm, rely on Arrow-M NFE Amber Relays.

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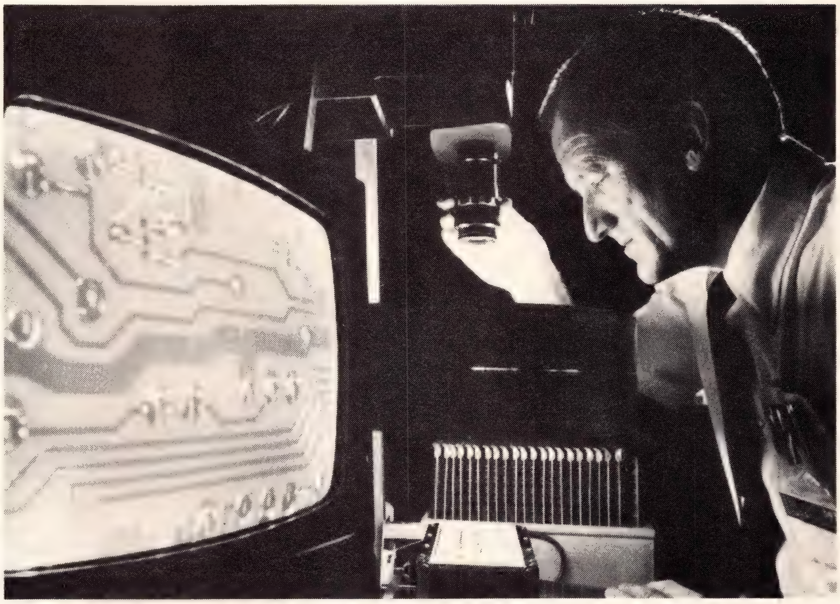
Sometimes, when you don't see the light can save you time and money

When harsh glaring sunlight makes it hard to see, you slip on a pair of polarized sunglasses to solve the problem. But what do you do if glare from shiny solder on pc boards makes it hard to see defects? Well, if you work at Western Electric's Oklahoma City Works and inspect thousands of circuit boards made for electronic switching systems, you don't put on polarized sunglasses—you switch on your VASDIS.



Glare is eliminated by illuminating a small area of a circuit board with polarized light, then magnifying and projecting it onto a TV monitor. Ben Sharp, inventor of the VASDIS unit, is shown adjusting the projected image for best visibility.

High-"light" imperfections

VASDIS, or Video Assisted Solder Defect Identification System, operates on the same principle as polarized sunglasses, and greatly facilitates some of the company's required inspection operations.

Any light, whether sunlight or fluorescent, is composed of both vertical and horizontal waves. The horizontal waves, bouncing off a surface, are responsible for producing glare; polarized light eliminates these waves and thus the accompanying reflection.

Ben Sharp, WE engineer and inventor of VASDIS, explained the problem. "For years, our employees had to check the hundreds of solder connecttions on our circuit boards with the naked eye. Reflections from the metallic solder surface made it difficult to see and catch all defects."

Before VASDIS, Western Electric maintained the defect detection rate at about 85% by inspecting each board three times under a variety of lighting conditions. While very impressive, such a rate proved inadequate because the circuit boards in question are used in sophisticated electronic switching systems. Understandably, the company goal was near 100% defect detection.

Results are almost perfect

The VASDIS inspection unit comes close—it operates at about 99% accuracy. Using a video system where contrast is easily adjusted for even better visibility, VASDIS projects an image of the board being checked onto a TV monitor.

The system can also magnify a selected board area five times its size without distortion. By narrowing down the field of view to an area roughly the size of a postage stamp, the system relieves eye-strain, as well as the need to "hunt" over a 5×8-in. circuit board for errors.

On top of all these positive factors, VASDIS offers another plus feature: During board inspection, the system allows the operator to make rapid solder repairs. In summary, the VASDIS unit will certainly make the inspector's job easier, and also save time, labor and thousands of dollars a year.—*TO*

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The ADAC Economy Series of software and mechanically compatible mini-computer data acquisition systems are for use with the DEC PDP-11, PDP-8E, F, M, A, and Data General computers.

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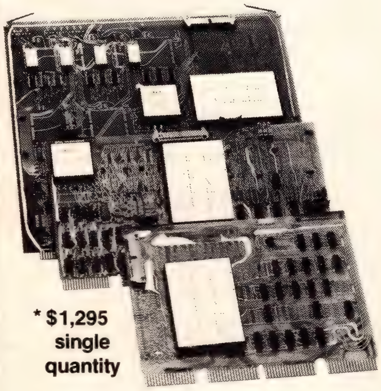


*** $1,295 single quantity**

adac corporation

For more information, Circle No. 23

Ambient light furnishes power to charge digital watch's batteries

A fresh approach to self-powering makes a new line of digital watches with LED readout unique. The units use rechargeable batteries instead of throw-away types. Also, the "solar" cells that charge these batteries feature emphasized response in the red and infrared region, thus providing output under sunlight and artificial illumination.

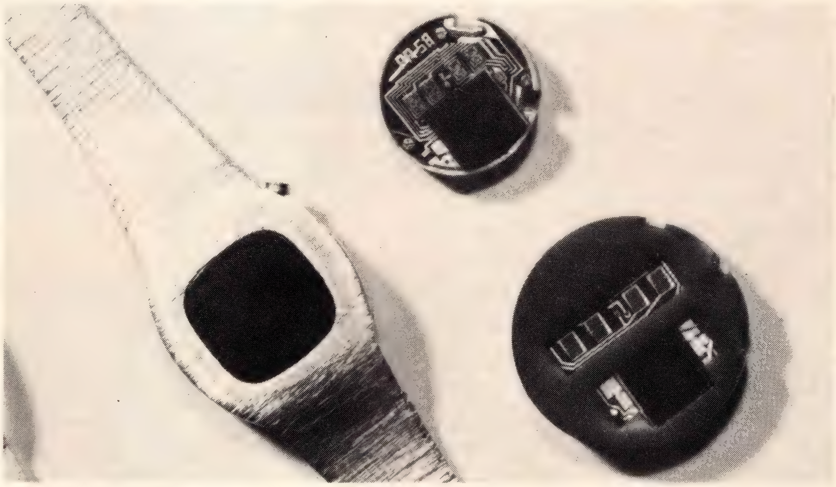
Matching the battery type to charging-source characteristics proved a key point in achieving successful operation, and P.R. Mallory's silicon-oxide zinc battery with trace elements exactly fits the need.

The spectral response of solar cells optimized for space or full-sunlight operation is generally tailored to make use of the high level of UV present. For this application, however, cells are fabricated with deep junctions that permit greater response to the red and IR content predominant in incandescent lighting.

Even body heat is claimed to activate these deep-junction cells sufficiently to produce a usable charge, raising the interesting possibility of a self-powered pocket watch.

Proof of the pudding

Putting this compatible "solar"-cell and rechargeable-battery combination to work at Pierre Rémy of Mt. View, CA resulted in their SolarCron™—a 6-function, LED-readout digital watch. This new timekeeper fits the same case as the company's digital watches powered by throw-away batteries, and should operate satisfactorily for at least three years before requiring battery replacement.—*ED*



Solar-powered watches retain the compactness of those that run on throw-away batteries.

Exposition will spotlight electric vehicles of all types and sizes

Next April thousands of industrial executives and government officials from all over the world will gather in Chicago to witness an event that few people would have predicted 10 years ago. They will be at the huge McCormick Place exhibition hall to attend the first International Electric Vehicle Exposition and

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model 4443
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LFE series 4400 DPM's can accept optional second printed circuit board to provide for most signal conditioning conversions. Complete boards available for linearized thermocouple, RTD, AC motor speed, power line, and other special inputs.

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ELECTRIC VEHICLES[1]

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DELIVERY VEHICLES	TROLLEY BUSSES
BUSSES	
MOTORCYCLES	OFF-ROAD
ELECTRIC BIKES	SUBWAYS
	RAILROADS
OFF-ROAD	PEOPLE-MOVERS
JITNEYS	TRACKED
GOLF CARS	GUIDEWAYS
MATERIALS HANDLING	MINE LOCOMOTIVES
FORK-LIFTS,	
OTHER PERSONNEL-AND BURDEN-CARRYING TYPES	
TRAINS[2]	
SILAGE CARTS	
LAWN MOWERS, GARDEN TRACTORS	
AIRPORT TUGS	

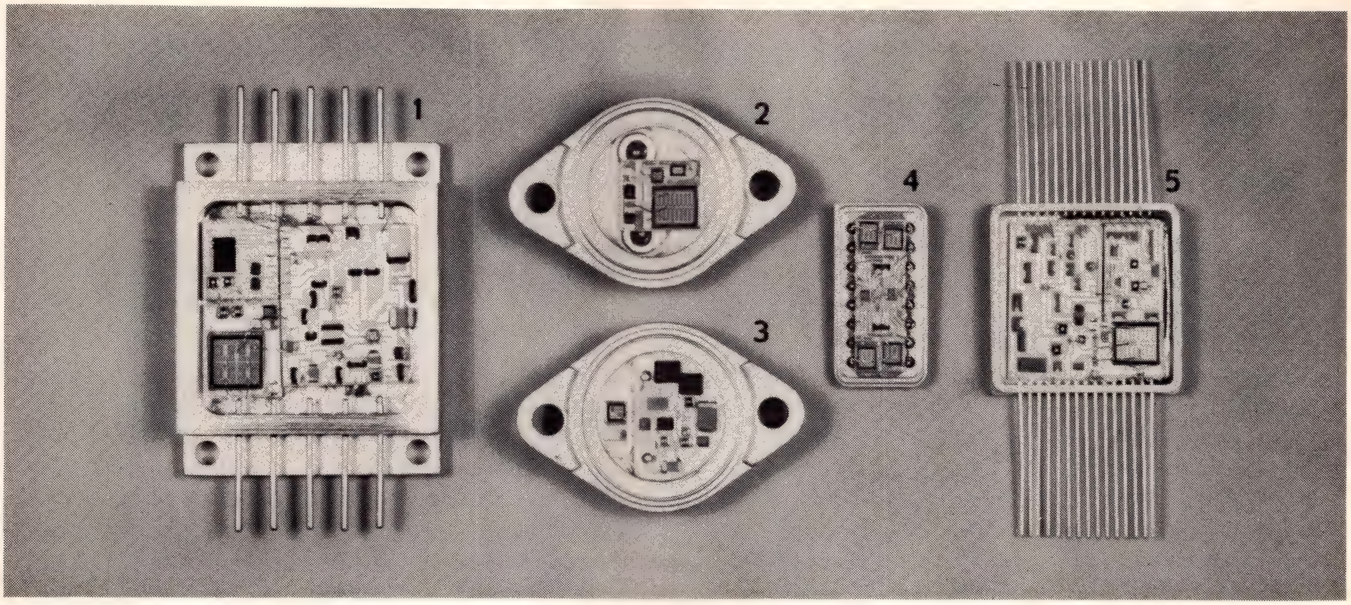
NOTES:
1. Vehicles using electricity as the primary source of motive power.
2. Although trains fall primarily in the right-hand column, battery-powered trains do operate in Germany. In addition, certain types of trains operate on batteries in tunnels where insufficient clearance exists for pantographs.

Energy conservation, ecology and economy all spur the development and use of electromotive power to move people and material. The International Electric Vehicle Exhibition and Conference will display equipment spanning a wide spectrum, as this table shows.

Conference—the largest U.S. show ever devoted exclusively to electrically powered vehicles. Displays will include electric railroad gear, personal automobiles, delivery vans, material-handling equipment, recreational vehicles and even hospital equipment.

The new show reflects the increasing world-wide interest in electric vehicles. Compared with equipment powered by internal-combustion engines, electrically powered vehicles offer substantial benefits: improved air quality, lowered noise pollution, greatly reduced petroleum consumption, reduction in overall energy consumption, lower cost of operation and lower cost of maintenance.

Because of the great impact that the market growth of electric vehicles will have on our industry, EDN will keep you posted on the latest developments in this field.—*WP*



Solitron Power Hybrids solve your space and weight problems

Solitron offers you new opportunities in hybrid design. We can combine our power transistors with low power circuitry into one package with no loss of thermal performance, and with greater reliability. The result is a completely packaged system which allows you to meet the tightest size and weight criteria.

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Solitron power hybrids meet MIL STDS. 38510 and 833 requirements with temperature performance over a −55° C to +125° C range. Our hybrid circuitry has proven its reliability in such major military programs as TOW, MAVERICK, AWACS, HARPOON, F-4, WILD WEASEL, STANDARD MISSILE and TWS, to name only a few. We also have extensive experience with commercial and industrial hybrid applications.

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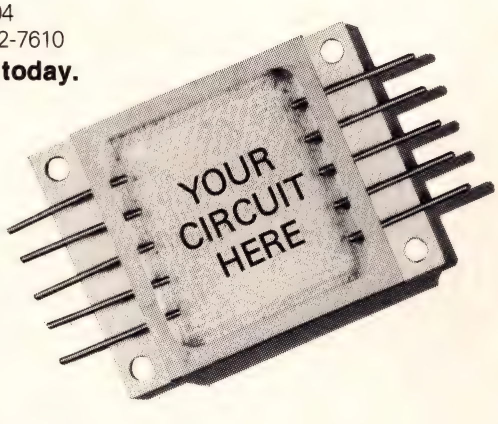


1. COPPER FLATPACK, Voltage Regulator, 300W dissipation; current up to 25A; voltage up to 100V; thermal resistance as low as 0.35°C/W; overvoltage protection. **2.** 3-TERMINAL TO-3, Planar Power Darlington, with stability resistors; NPN or PNP; up to 30A capability. **3.** 3-TERMINAL TO-3, 3A Series Voltage Regulator; positive or negative fixed output; 5V to 80V. **4.** 16-PIN DIP, 4 Output Dual Power Lampdriver; 1A capability; designed for high surge capability. **5.** 30-LEAD FLATPACK, 5A Voltage Regulator; insulated beryllia bottom; 5V to 50V; positive, negative or both.

ALL ILLUSTRATED PACKAGES ACTUAL SIZE AND PROVIDE:
high circuit flexibility; multiple power chip capability; alumina or beryllia ceramic substrates; high reliability; hermetic seal; gold-silicon eutectic alloy die attachments; ultrasonic aluminum lead wire attachments.

For more information, Circle No. 32

A computer in every home? Thanks to the μC-hobbyist boom, it's coming a lot faster than you might imagine!

John Conway, Associate Editor

The introduction of the μP caught most discrete (7400, etc.) digital-logic designers and almost every OEM with their proverbial pants down. Management in many companies (with a few exceptions), not knowing if the μP would fly or die and unwilling to risk substantial amounts of capital on an unproven device, usually permitted only one or two staff EE's to investigate the "bug" on company time. This effectively shut out the remaining staff members from a budding technology—designers who were rapidly coming to realize the μP's significance.

This scenario repeated itself in the educational/student realm as well. The result? Faced with the possibility of being left in the "daedalian dark," many "shut-outs" purchased components and assembled systems with their own funds—learning the in's and out's of the microprocessing game during their spare time.

Much to their surprise and chagrin, these do-it-yourself μP'ers discovered they'd enrolled in the School of Hard Knocks (component/system availability, reliability and documentation were in a tragic state).

The hole becomes a dough-nut

In December 1974, Popular Electronics Magazine published plans for a very low-cost terminal suitable for a kit-form microcomputer (new buzzword) that would be described in their January issue. Within days, readers overwhelmed Micro-Instrumentation Technology Systems' (MITS) 20 employees with letters requesting additional info on the 8080-based $990 Model "8800."

"After the January issue hit," recalls MITS V.P., Dave Bunnell, "we sold like crazy."

Why the popularity? MITS had inadvertantly created a product that eliminated the bulk of the nuts/bolts/documentation hassle—exactly what the machine "shut-outs" demanded. Within weeks, other companies—including IMS Associates, Southwest Technical Products, Sphere, and the Digital Group (many founded by shut-outs themselves)—jumped on the bandwagon. Like MITS, most were small, garage-sized, hobbyist-oriented firms or companies formerly involved in μP research and development.

In a fashion reminiscent of the post-WW II surplus boom (that created manufacturers such as Hewlett-Packard, et. al.), a whole new "cottage industry" sprang up overnight.

The computer store arrives

"The world's first consumer-computer store" opened its doors in the summer of '75. Public response was incredible and business was far better than owner/operator/custodian Dick Heiser had ever imagined.

"I tried to be as optimistic as possible," he said, "but that turned out to be too conservative. You have to be wildly optimistic."

Now, rather than having to wait months for a back-ordered MITS 8800 or SWTP 6800 etc., microcomputer buffs could inspect, fondle, and purchase the calculating engine of their choice—over the counter. More importantly (as many distributors discovered), customers could present technical problems, swap software or just shoot-the-breeze with store owners—a nice personal touch. Like their hobby-μC manufacturer parents, these stores began to proliferate as well.

Computer stores in high-technology regions—such as Massachusetts and Southern California—found themselves with standing-room-only crowds of "BS"-ing customers at lunch-times and after working hours.

"Gadzooks!" someone thought, "Why not form a club?"

Walk tall and carry a big club

As you might imagine, clubs sprang up, attracted all sorts of people, and well, we've just caught up with the present.

What happens at a computer club and why the tremendous interest?

We can answer the latter in five words, "The Power of the Masses." Hobbyists quickly learned the meaning of the phrase "substantial discounts in OEM quantities" and pounced on it with a fervor quite surprising to unassuming semiconductor houses and other μP suppliers. Many "computerists" (a term coined by the New England Society—NECS) need memories, peripherals, and hardware that quantity buying can place in their hands with savings as high as 60% off list.

Do hobbyists spend money ?

Recent estimates show that the average computerist has already spent $1000 to $2500 on his hobby—often blowing (a computer hack term) $500-$800 in one sitting!

The power of the masses works in another way, too. As a group, club members usually separate into two piles—hardware-oriented types and

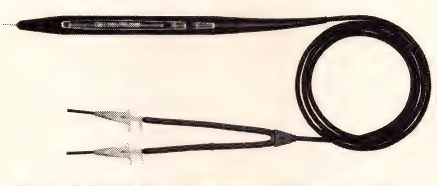
We've just revolutionized digital troubleshooting. Again.

This time we've done it with a Current Tracing Probe and a Multi-Family Logic Pulser, Probe and Clip.

HP's hand-held logic troubleshooting instruments bring dramatic new capability, speed and convenience to locating logic faults. Use them alone or as a synergistic team to save time, money and frustration. They're the latest wave of the IC troubleshooting revolution we started when we introduced the first logic probe, logic clip and logic pulser.

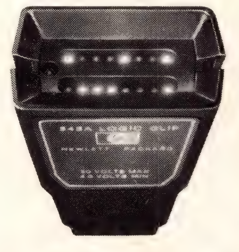
A Probe that Traces Current! As shown above, the Model 547A Current Tracer's tip lights when on or near a conductor carrying digital current pulses from 1 mA to 1A—in any logic family. Now you know where the current's flowing so you can quickly fix stuck nodes without cutting circuit board traces or removing and often damaging good ICs or microprocessors when searching for bad ones. Now you can quickly find solder bridges and backplane shorts, troubleshoot wired AND/OR busses or three-state busses.

A Logic Pulser That Does More Than Just Give Single Pulses. The new 546A Programmable Logic Pulser (above) gives one pulse, a 1,10 or 100 Hz pulse stream, or a burst of exactly 10 or 100 pulses. Now you can rapidly set your circuit to any state you wish. It's a voltage and current source that provides the controllable stimulus you need for troubleshooting. It'll drive TTL or CMOS high nodes low or low nodes high.



New Multi-Family Logic Probe. The HP 545A tests most positive families including TTL and CMOS. An unambiguous single lamp at probe's tip quickly indicates logic high, low, bad level, pulses, pulse trains. Its built-in pulse memory catches elusive transitions that occur when you're not looking.

New Multi-Family Logic Clip. The Model 548A's 16 LEDs show logic states of 16 IC pins at once, revealing the circuit's truth table. It automatically adapts to TTL, RTL, CMOS and HTL and automatically seeks Vcc and ground. It draws <15 μA per pin, yet is overload protected to 30 Vdc.



Prices: HP545A $125, HP546A $150, HP547A $350, HP548A $105, Domestic U.S.A.

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For assistance call: Washington (301) 948-6370, Chicago (312) 677-0400, Atlanta (404) 434-4000, Los Angeles (213) 877-1282, Toronto (416) 678-9430 software-oriented types. With so many similar-interest people in one place as well as a large variety of practical knowledge, meetings permit members to "brain pick"; i.e., learn from each other's mistakes. Thus, hardware freaks learn from their soft-headed comrades and vice versa. Everybody's happy.

But we still haven't answered the "what happens at a meeting" question. Let's follow a session from start to finish.

A logical kind of seminar

Meetings are usually held in "temporarily donated" corporate or college auditoriums or cafeterias once or twice a month around 7 PM. They begin with five to 10 minutes of routine club business but quickly get to the main event—one or two technical sessions presented by individuals well-versed in a topic of particular interest (like TTY maintenance). Remarkably professional, the sessions last 30 to 60 min. with questions and answers allowed throughout.

An "intermission" of 10 minutes or so often follows, at which time the "hustlers" in the group can sell surplus hardware, software or other "junque."

Intermission concludes with a "mapping-session," a rather unique Q and A séance where a club member can stand, relate a problem such as: "My F8 won't run," and hope to have someone across the way stand and reply..."I know what's wrong! Let's talk." "Klugey" as it sounds, "mapping" really works—saving many "hacks" countless hours of hard and soft debugging.

Mapping terminated, the club members break up into smaller groups for more specialized discussion. One "microsession" team might talk about wire-wrapping, another about the Motorola 6800, another how to "roll your own" pc boards, still another the intricacies of a Star Trek space-war game.

The microsessions bring the meeting to a close as many discussions go on until the wee hours.

Where do we go from here?

Is the computer hobbyist a flash in the pan or the beginning of a "new breed?" Most industry sources, skeptical until only recently, now predict that the computerist is definitely here to stay. In fact some crystal-ball gazers foresee ultra high-level language consumer-computing "Information Centers" in homes as early as 1980, with sales exploding possibly faster than present-day personal calculators and citizen-band radio. □

How many ITT Components Group PZSM PCB relays can fit on the head of a single Potter & Brumfield T10?

☐ Three ☐ Five
☐ Four ☐ Six

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To get the relay that fits your function . . . PZSM, RZ, LZ, or MZ . . . check the chart below. Call or write Bob Scanlon today at (617) 688-1881 for your complete relay catalog and free relay samples. Tell Bob you want to experiment with the better alternative. And try our six-on-one test yourself. ITT Components Group, 1551 Osgood St., No. Andover, MA 01845.

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Height	0.36 in.	0.43 in.	0.56 in.	0.39 in.	0.37 in.
PCB Space	0.29 in.^2	0.30 in.^2	0.52 in.^2	0.25 in.^2	1.78 in.^2
CONTACTS					
Load	0.5A	1A	3A	1A	3A
Form	2C twin	2C crossbar	1C	1C	2C twin
Material	Au-Ag alloy	Ag	Ag	Au-Ag	Au flash Ag
COIL					
Voltages	5-6-12-24	4.5-6-12-24	5-6-9-12-24-48	1.5-3-5-6-9-12-24	6-12-24-48
Average Power	170mW	525mW	330-450mW	450mW	300mW
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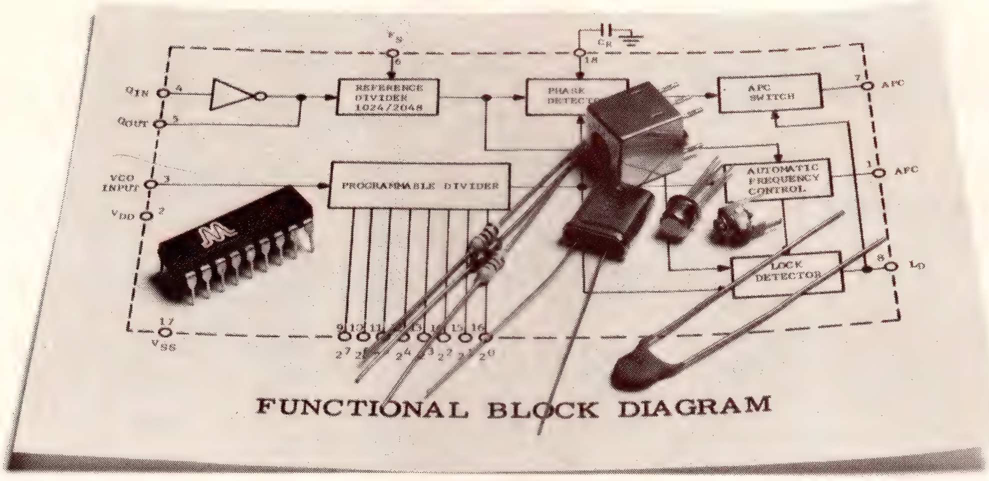
Lower the cost of multi-channel communications.



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SOC 2-10	C	2V	10.0	8.0	6.5	67
SOC 5-3	A	5V	3.0	2.4	1.8	32
SOC 5-6	B	5V	6.0	4.9	3.8	54
SOC 5-10	C	5V	10.0	8.0	6.5	67
SOC 12-1.6	A	12V	1.6	1.3	1.0	32
SOC 12-4.0	B	12V	4.0	3.0	2.5	54
SOC 12-6.0	C	12V	6.0	5.0	4.2	67
SOC 15-1.5	A	15V	1.5	1.2	1.0	32
SOC 15-3.0	B	15V	3.0	2.6	2.2	54
SOC 15-5.0	C	15V	5.0	4.2	3.5	67
SOC 24-1.0	A	24V	1.0	.75	.55	32
SOC 24-2.2	B	24V	2.2	1.9	1.6	54
SOC 24-3.5	C	24V	3.5	2.9	2.4	67
SOC 28-0.8	A	28V	0.8	.64	.45	32
SOC 28-2.0	B	28V	2.0	1.7	1.4	54
SOC 28-3.1	C	28V	3.1	2.6	2.0	67

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Common Specifications:

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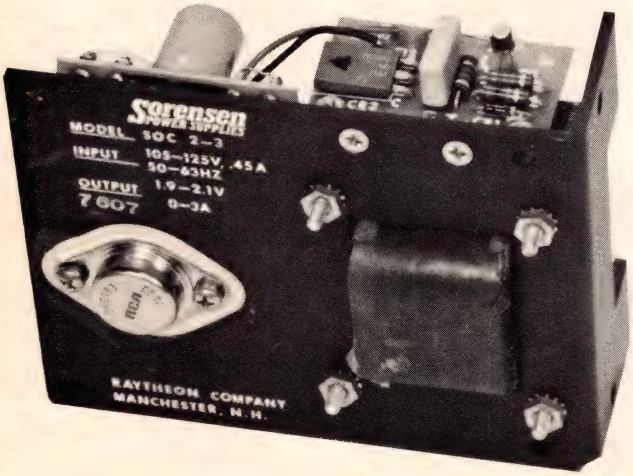

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µP APPLICATION IDEAS

Programmed dicing saw slices wafers easily and precisely with µP's help

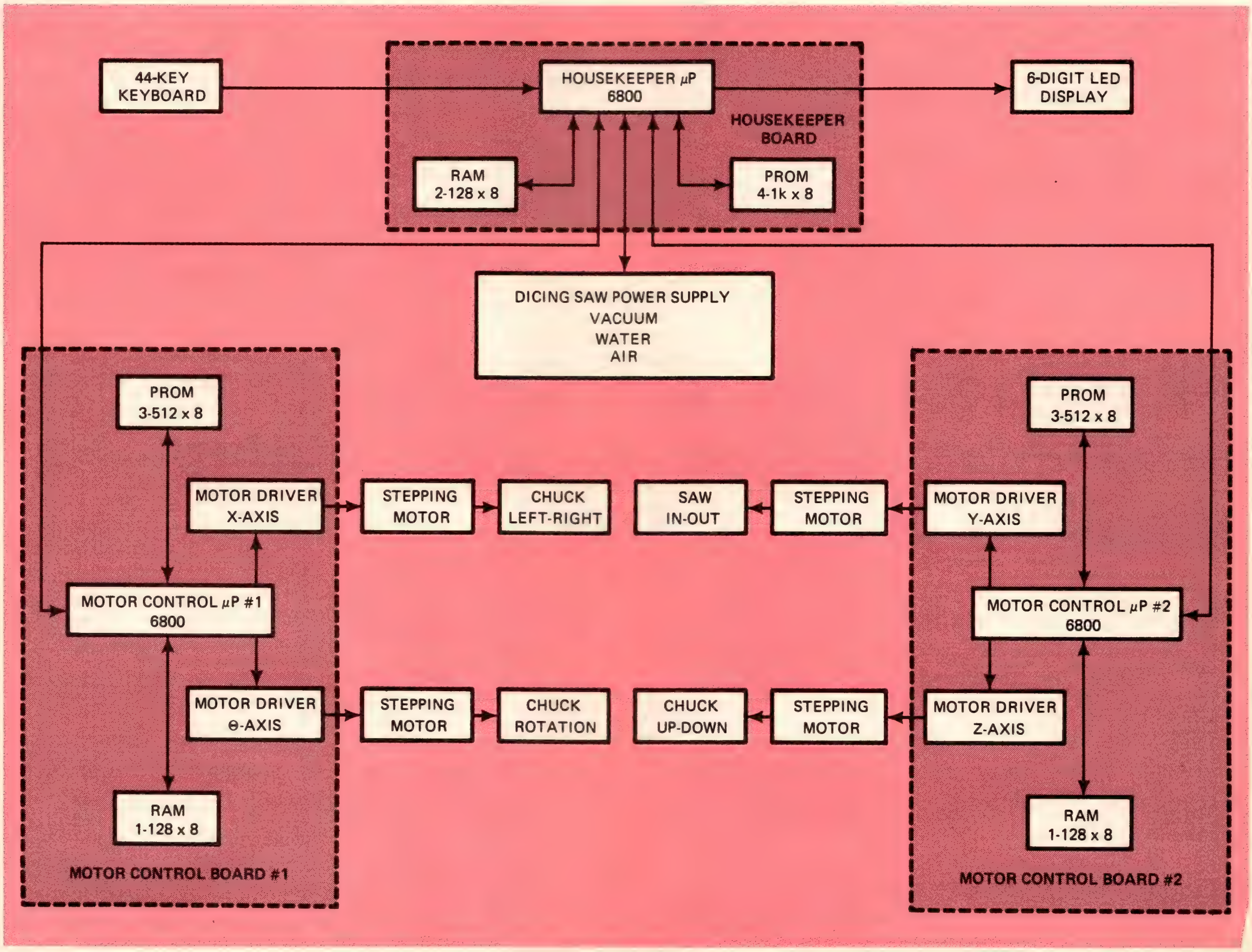
The Model 1000, an innovative, programmed dicing saw introduced by Micro Automation, Inc. of Santa Clara, CA, uses three µP's to cut wafers up to 5.25 in. in diameter. This saw achieves new levels of yield, speed and automation; and, unlike in traditional scribing and breaking operations, Model 1000 produces an undisturbed chip array ideal for automated bonding techniques and reduces irregular crazing.

Controlled in four axes (X, Y, Z, and Θ), the device either completely separates the dice, or cuts far enough into thick, large diameter wafers to eliminate cracks that could reduce yield.

Reduce potential operator error

To run this unit, an operator first mounts a wafer on the vacuum chuck and aligns the specimen while observing the operation through a microscope. He then enters the desired die dimensions, cutting speed and other data which simultaneously appear on the 6-digit LED display; and if correct, feeds them into the programmed instruction set. The Model 1000 then finishes the job with no further operator assistance other than pushing the "CUT" button.

This unit offers a number of features over conventional dicing saws as a result of microprocessor implementation: It accepts program inputs in either English or metric units without hardware changes, and affords very high resolution for exact cutting of the odd chip sizes that result when a semiconductor firm "shrinks" its



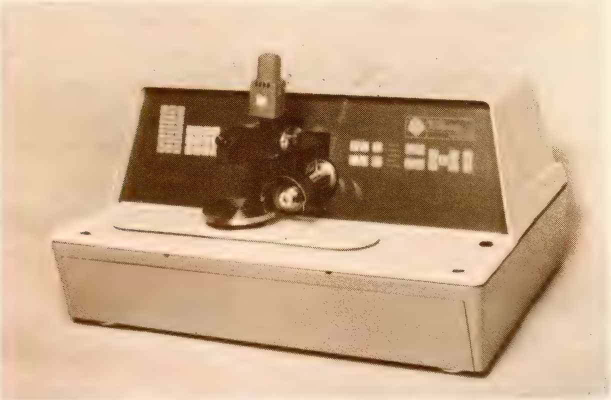
Most of the electronics for this system sit on three boards, each containing a single 6800 microprocessor. The "housekeeper,' however, controls the entire system; the other two are used only to run the motors.

mask for greater numbers of dice per wafer.

The saw cuts at variable velocities: fast through the center of the wafer but slow when entering or leaving it to prevent cracking or chipping. The unit also scans only the actual wafer area rather than a large square, increasing throughput.

This housekeeper runs the show

Closed-loop stepping motors that increment 200 times/revolution control saw movement in the four axes. Two 6800 microprocessors, one on each motor-control board, act as peripheral controllers for these motors. Data speed constraints, however, allow each 6800 to control only two such motors, and even then, both cannot run at full speed simultaneously. A third 6800 handles other "housekeeping" functions such as scanning the panel, watching limit switches and making calculations besides maintaining total system supervision.



An attractive front panel on the Model 1000 programmed dicing saw allows entry of program operations on the left, while push buttons on the right permit complete control of the entire process. The operator reads lighted indicators to receive instructions and follow operation progress.

This system currently uses EPROM, but plans include provisions for PROM or even ROM as program and function development wraps up and volume grows. The random access memory utilized for slicing-data storage operates from a separate, always-on power supply so that the unit maintains overnight storage.

A watertight plastic panel with integrated flexible push switches common to many calculators protects the saw's control panel. A program input group, an operating control group and a standard decimal keyboard facilitate machine set up, while prompting lamps assist the operator through the short process sequence and give notification of any errors.

Software needs development time, too

Micro Automation's Barry Gottlieb noted that this was MAI's first venture into μP's, and he discussed some of the surprises the company found: "Software presented our biggest problems—not that these couldn't be solved, but the time required was unexpected. We spent five months, from the first rough drawings to final assembly, to build the prototype. We then had a unit that sat there, smiled, and looked pretty—but couldn't do anything because we hadn't finished developing the software! That, too, required a total of five months, just as long as hardware development. But this was our first attempt at working with microprocessors, and we expect the knowledge we've gained to give us a big competitive edge in any future efforts." □

μP replaces cam controller in environmental test chamber, adding simplicity plus accuracy

Until recently, programming an environmental test chamber required much time and patience. But Tenney Engineering, Inc. of Union, NJ recently introduced its DigiTenn programmer, which allows software-control development at a fraction of the time of a standard cam-driven system while amplifying control capabilities many times over.

Programming with a saw and a file

A cam controller consists of a circular disc (12 in. in diameter) which rotates on a cycle that can be hours or days long. A resistive network, whose value is regulated by the loacation of an arm on a track cut into the cam, sets the value of a particular parameter, usually temperature, humidity or pressure.

A cam, however, requires more than a quick "cut" to program. The programmer makes the initial cut high, then files the metal or plastic disc down until he finds, by trial and error, that the cam gives the correct instructions. A typical 6-in. cam radius may represent a temperature span of −125 to +350°F, (almost 80°/radial-in.), so the smoothness of a single cut can make several degrees' difference. Thus, when concerned with

FLUKE PROVES AN INEXPENSIVE, HANDHELD DMM CAN BE BUILT WITHOUT LEAVING EVERYTHING OUT.

Let's face it.

Before now, if you bought an inexpensive, handheld digital multimeter you didn't get much— they just left most everything out.

We knew that was no answer.

So we built the 8030A 3½-digit DMM. It's a small, portable, inexpensive, handheld DMM, but it performs like our benchtop units.

With one basic difference. The 8030A was designed, built and tested to a size and shape proven best for field service and laboratory technicians. There's a built-in hood that can be slipped forward to shade the readout in sunshine. It has rms capability. The best overload protection. Diode test. It weighs 2.2 pounds, and will take a beating without failing. Finally, we guarantee accuracy specifications for one year.

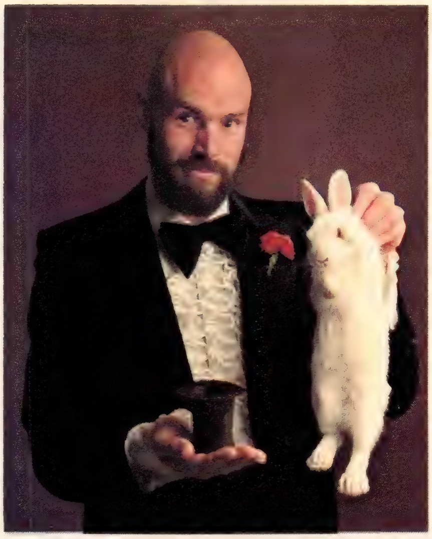
And it only costs $235*.

True rms.	Fluke
1-year accuracy specs.	Fluke
High voltage protection.	Fluke
Diode test.	Fluke
A full line of accessories offering rf voltage, high current ac, high voltage dc, and temperature measurement probes.	Fluke

There's only one place to go for all the performance you need in a handheld DMM.

There are measurement functions in five selectable ranges for dc volts, ac volts (true rms), dc current, ac current (true rms), and resistance. DC voltage measurement is from 100 μV to 1100V with basic accuracy of ±0.1%, ac measurement is from 100 μV to 750V rms with basic accuracy of ±0.5%. DC and ac current is from 100 nanoamps to 1.999 amps with basic dc accuracy of ±0.35% and basic ac accuracy of ±1%. Resistance measurement is from 100 milliohms to 2 megohms with a basic accuracy of ±0.4%.

We added true rms response for ac measurements. Specified accuracy is still attainable when the measured waveform is distorted.



"Fluke does the impossible again."

There is extensive overload protection. It has been tested with transients up to 6000V peak across the input terminals.

Options include two battery operations: a rechargeable NiCad for 8 hours operation and throw-away alkaline cells. Accessories include probes for measurement of rf voltages, high current ac, high voltage dc and temperature.

80T-150 Temperature Probe

Sensitivity:	1 mV/°C or 1 mV/°F
Accuracy:	
+15°C to +35°C ambient:	±2°C(3.6°F) −25°C to +125°C ±3°C(5.8°F) −50°C to −25°C and +125°C to +150°C
0°C to 15°C, 35°C to 50°C ambient:	Add 1°C(1.8°F) to above

You can also get temperature measuring capabilities with the 8030A.

And because the 8030A gives you so much in performance, let us remind you once more of the price.

Only $235*.

For the first handheld DMM that's small in size, small in price, but huge in performance.

For data out today, dial our toll-free hotline, 800-426-0361.

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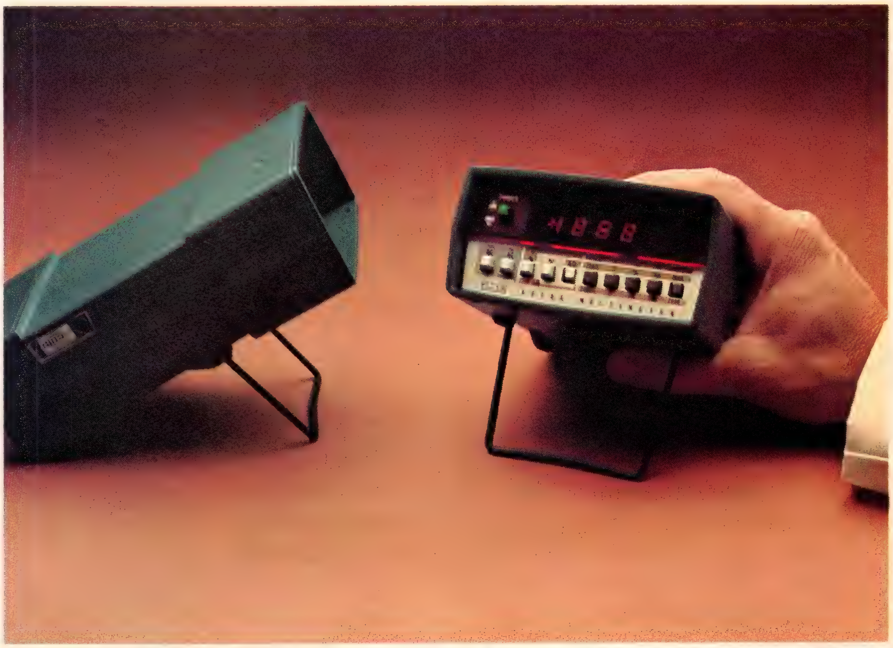

A NEW ADVANCE. 8030A DMM. FLUKE®

For demonstration, Circle No. 37
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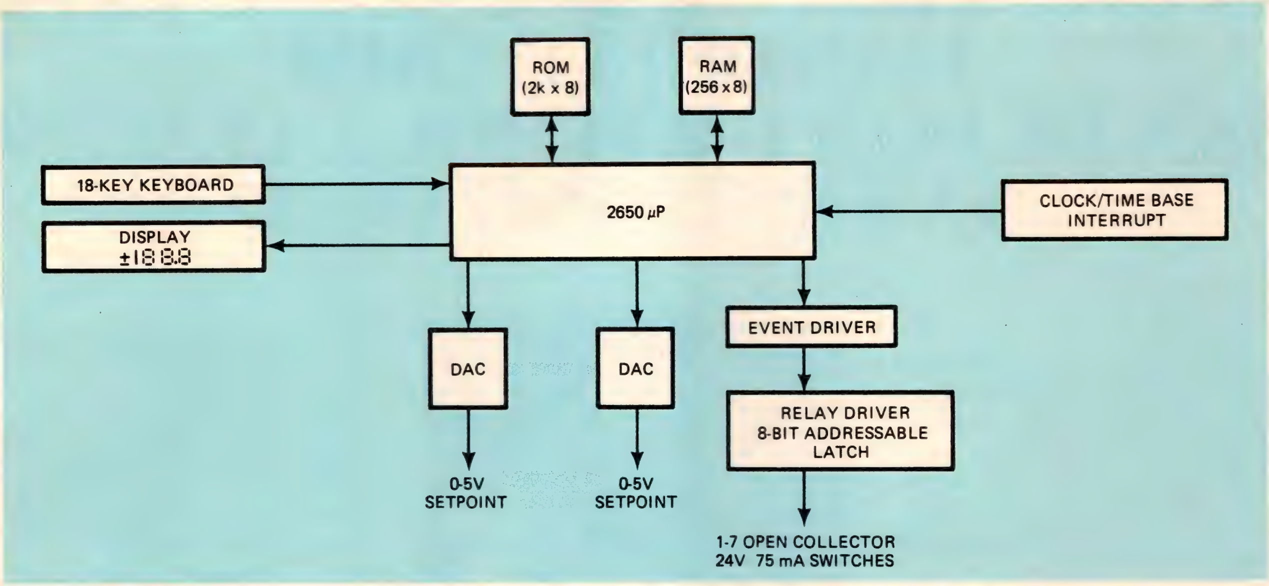


Besides its ease of programming, the DigiTenn offers great output capabilities. The relay drivers activate external equipment while the DAC's act as setpoint controllers—one for temperature and the other for temperature or humidity.

precision control, cam programming can be difficult as well as time consuming.

The cam approach also encounters rate-of-change limitations. An arm cannot track the transition from a low point to a high point except over at least several minutes of time; instantaneous changes are impossible. Closely regulated rates of change also present difficulties.

The advantages of a µP controller over the mechanical system thus stand out sharply: To program the DigiTenn, one need only write in a series of program points using the 18-key keyboard. These points represent specified combinations of time and other parameters, with each adjacent point modifying one or more of these parameters. No restrictions on rate-of-change exist, and upon predetermined conditions, the DigiTenn activates peripheral equipment, such as shakers or the test specimen, without the external timers required by conventional controllers.

These significantly greater capabilities make the DigiTenn particularly well suited for high-accuracy testing, as in military specifications.

Efficiency, not speed, counts most

Tenney went to Research Inc. of Minneapolis, MN for assistance in developing this system's electronics. Project engineer Clarence Lilienthal explained that this application does not require great speed, but does demand efficient memory utilization. Thus, the powerful addressing modes of the Signetics 2650 contributed to the selection of this 8-bit n-channel processor.

The 2650 chip accepts up to 16 program-point inputs (expandable to 40) and routes each into eight bytes of RAM. Defining the environmental chamber's routine, these points are either typed in on the keyboard or, for common routines, read from a PROM. Upon receipt of these points, the µP performs a straight-line approximation between them to define the complete control-

Has a µP helped YOU lately?

EDN's µP Application Ideas section appears as a regular feature of every issue, presenting a designer's view of microprocessors in action. We select unique and interesting applications that illustrate the many different ways that µP's are being used in new products or systems. Emphasis is on the functions handled by the µP, features of the product or system made possible by the µP and advantages of the µP approach over others.

Have you designed and developed an interesting µP-based product? If you have, then please tell us about it. Your description should state the problem, indicate previous or alternate solutions (if any), explain basically what the µP is doing, discuss the µP's advantages and describe any design difficulties encountered. Concentrate your remarks on the µP. To complete your story, please include a block diagram and at least one black and white photograph of the product.

Send your entries:
µP Application Ideas
EDN
221 Columbus Ave.
Boston, MA 02116

IT WAS BOUND TO CAUSE DOUBT, CONFUSION, WORRY AND A LITTLE PANIC.

Before the 6011A came along, a lot of people thought they knew who made the best signal generator.

Now, there's doubt and confusion.

We started with the best everyone else had. Then, we began our serious design work on the 6011A—a new, microprocessor-based signal generator. And along the way, we also solved the problems of setting frequencies and amplitudes. There had to be less dialing, and no time standardizing. We decided to get rid of all the unnecessary adjusting. And let the microprocessor do the work for you.

People are finding they can't just buy that comfortable old name, with the same old features. Fluke has a signal generator that does a whole lot of things that no one else can do.

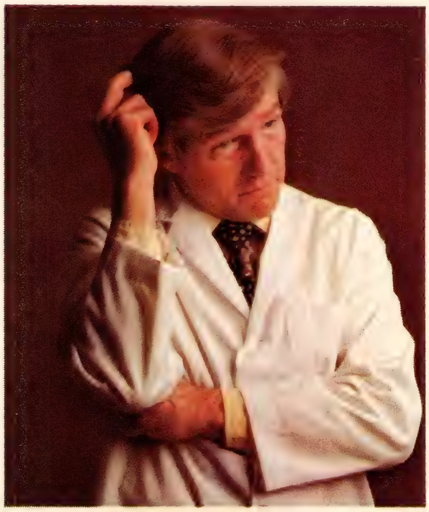
Read on. You'll see why the competition is a little panicky.

The 6011A performs the functions of an oscillator, counter and level meter setup over a range of 10 Hz to 11 MHz, within amplitudes ranging from 0.4 millivolts to 5 volts rms and −55 dBm to +27 dBm. And does it fast.

The microprocessor stores up to nine combinations of output settings in memory. That's frequency and amplitude combinations, with modulation and range settings. Particularly important for repetitive tests at several frequencies and amplitudes. Less time. No operator error. A push of the button recalls the setting.

We had a few people test the 6011A. Using the 6011A recall capability, they could call up nine different frequency and amplitude combinations within four seconds.

Once the setting is called up, edit control lets you modify your frequency or amplitude with a simple turn of a dial. Any decade, as indicated by the brighter digit on the readout, can be changed. Increment or decrement with complete carry and borrow capability. And a recalled frequency or level can be modified without changing the original stored entry.



"How much better can a signal generator be?"

The reference mode lets you add or subtract frequencies or levels relative to previously entered references.

Level limit eliminates damage to sensitive devices. The operator can't use an output greater than a pre-programmed safe limit.

The 6011A is designed for free form entry of volts, millivolts, dBm, Hz, kHz, and MHz. For example, output levels entered in volts can be modified in decibels to a resolution of 0.01 dB. The user can select volts peak-to-peak or rms volts terminated in 50 ohms or open circuit. Maximum open circuit voltage is 28.28 volts peak-to-peak. At 11 MHz!

Accuracy is so good there's no need for output verification. An rms sensor controls the output accuracy to better than ±0.05 dB. Frequency response is flat to within ±0.025 dB from 100 Hz to 5 MHz. Output frequency accuracy is within 3 ppm over a one-year period and a wide temperature range.

Finally, we kept the price way down. At $3995*, the 6011A is 40% less than anything remotely comparable.

About now, are you beginning to feel you're going to expect a lot more from your next signal generator? Well, ask for a 6011A demonstration first.

And find out how much you can expect from a signal generator.

For data out today, dial our toll-free hotline, 800-426-0361.

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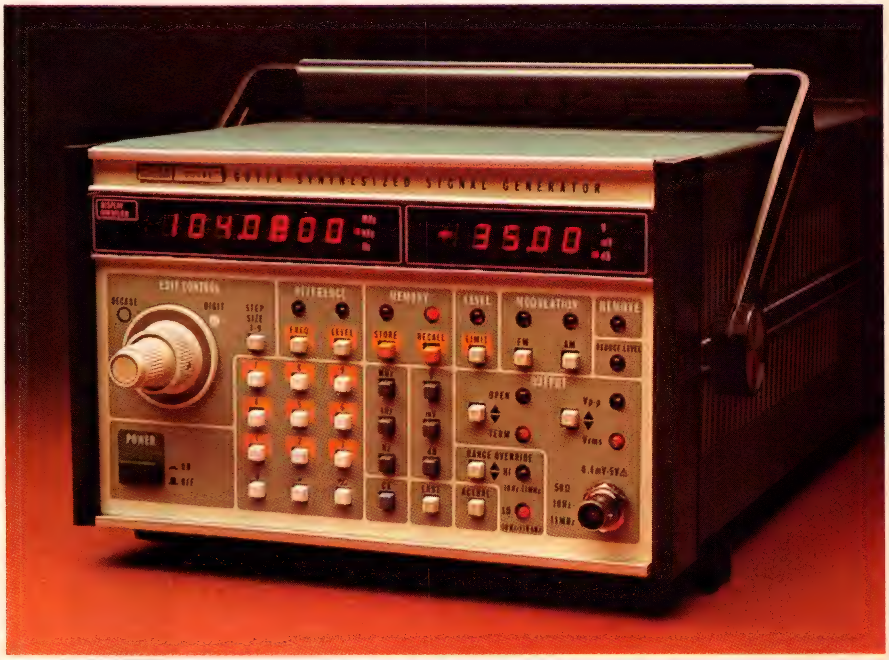

INNOVATIVE 6011A SIGNAL GENERATOR FLUKE®

For demonstration, Circle No. 42
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Environmental test chamber controller developed by Tenney Engineering, Inc. offers quick easy programming in a small attractive package. This unit can also replace controllers on existing environmental chambers with minimum retrofitting.

function curve, then actually regulates the chamber with seven event (or relay) drivers and two D/A converters. Information concerning event status, the D/A outputs, program step, time into program or other functions appears on a 3-1/2-digit display.

A crystal-controlled time base establishes time of day as well as relative program time; thus the chamber may be programmed to automatically activate at any specific time.

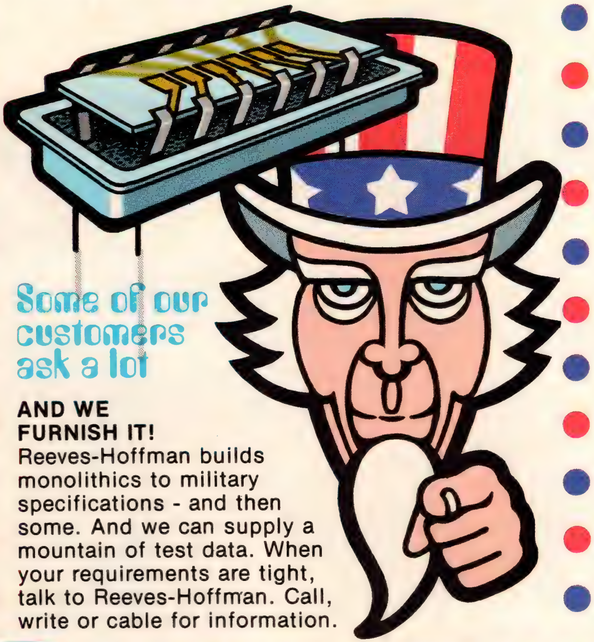
The 2650 makes no special external interface demands, and the chip itself is relatively inexpensive. As a static processor, able to advance one clock step at a time, the device was easy to breadboard and troubleshoot, Lilienthal added.

One slight problem did crop up during development, however. Research Inc. found that the 2650 needed an assist (in this case, a 3-step program in RAM) to return to the main program after an interrupt. (Signetics responded that this situation will soon be remedied in the 2650A, whose instruction set will include two additional commands that make a return more efficient.)

μP saves on extras

Along with outperforming its mechanical forerunner, the μP system with either one- or 2-parameter control capabilities also costs about $800 more than the cam-controlled system. However, during an event-activation situation where the cam-controller would require additional equipment, this price differential may drop below 20%, not very significant when considering the ability and accuracy provided by the μP system. ☐

Article evaluation: Please circle one on R.S. card.
Read Some—No. 301 Read Most—No. 302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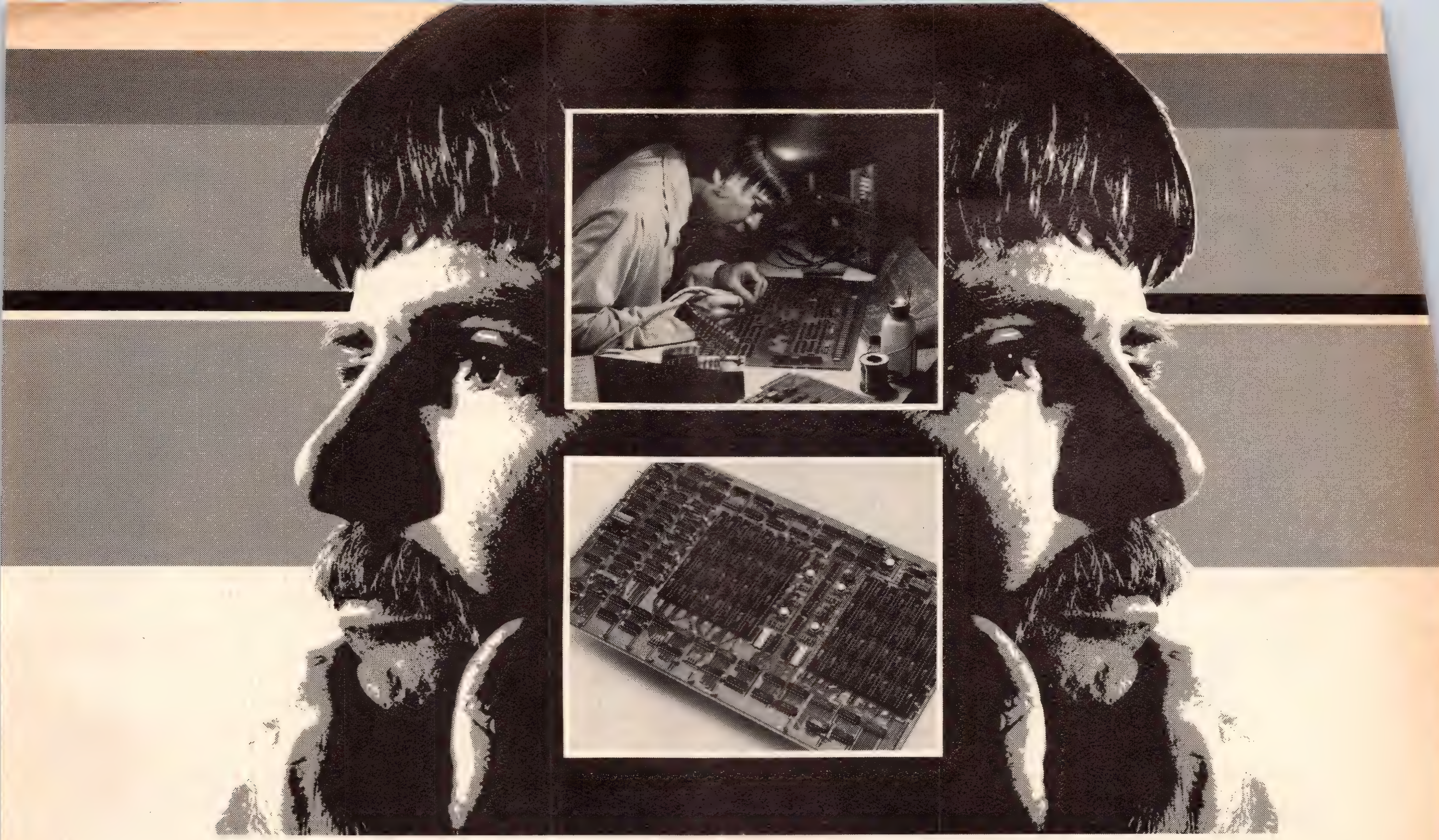

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And think MONOSTORE® to save valuable development and production time because MONOSTORE gives you:

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And our production and test procedures assure that we use only the *best* components in your MONOSTORE product. We use only full-spec components, and we test to assure those specs. Our stringent tests pull the "clunkers", the pattern-sensitive, heat-sensitive, and the voltage-margin failures. Burn-in takes out the "infant mortality". And then MONOSTORE memory systems are computer tested for proper function. That all takes time, but it pays off by removing defective components, and by building product confidence. That confidence is important when you're busy debugging your new software.

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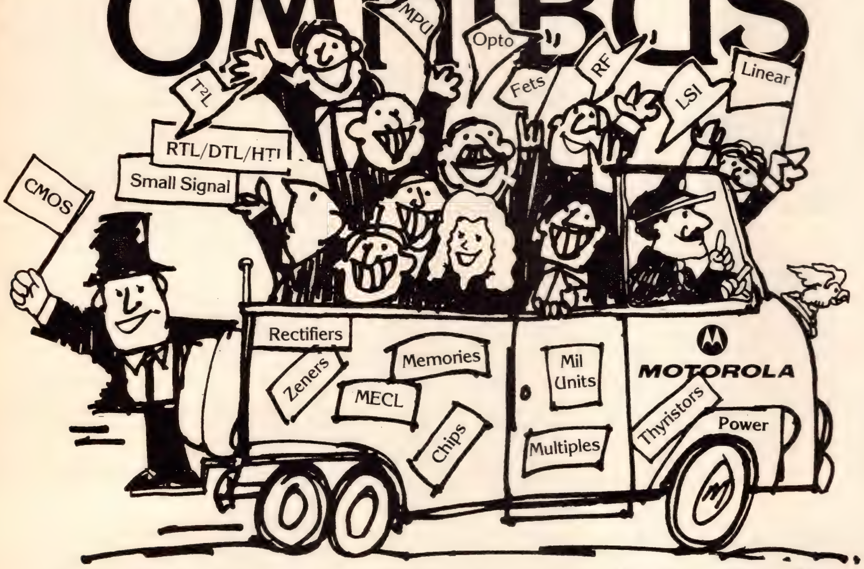


Rollin' along the routes to right design

Kiss input polling routines goodbye

Bon Voyage and good riddance to input polling routines for your microprocessor systems. Send them packing first class at strictly coach fares with the new MC8507/ MC6828 Priority Interrupt Controller.

What's that? Why two different numbers for one LSI device? No, not a split personality. We just want you to know this PIC is bipolar LSI (MC8507) designed to work in any processor system, but its first and foremost function (MC6828) is serving M6800 systems as if it were a member of that renowned NMOS family. Either number can be used for ordering.

Basically, the purpose of the PIC is to generate a modified address to ROM in response to prioritized inputs. Each interrupting device is assigned a unique ROM location with the starting address of the appropriate service routine. After the MPU responds to an interrupt, the PIC directs it to the proper memory location. The PIC also generates a Stretch signal, so the interrupt structure can be designed to accommodate the faster operations anticipated with improvements in processor speeds.

You'll just love it.

SUPER-DUPER MOSFET QUIZ:

'Tis better to 1 enhance it
2 deplete it
3 tube it

If you're into #3, this isn't for you (or maybe it is). But if you're after the best in MOSFETs for present and future VHF two-ways and TVs, receive this message:

Good 'ol Motorola now supplies the popular 'ol 3N201-03 family of N-channel, depletion mode dual gates plus the new DMOS enhancement mode MFE521.

The '201s, of course, offer typ common-source G_{PS} of 20 dB and typ NF of 1.8 dB. The '203, generally used for IF, has 25 dB G_{PS} typ.

And if you promise not to tell TI, the series duplicates theirs — for which you may be thankful — and is priced comparably — for which they won't be.

For your next generation of amplifiers/mixers, we present MFE521 in all its super-duper enhancement mode and ion-implanted splendor for just 60¢. It has 0.02 pF max reverse transfer capacitance and diode protected gates. At 200 MHz, common-source G_{PS} is 25 dB and NF 1.7 dB typ. Input and output capacitance, at 1 MHz, are 3.3 pF and 1.1 pF typ.

All are in hermetic TO-72's and can be had just by quizzing our super-duper salesmen. Don't ask about tubes — they know FETs, not filaments.

Advance and be RECOGNIZED, said UL, so we did.

And we are.

To prove it, we'll send you **the yellow card!**

For the unamazed among you, a UL-issued "yellow card" for an electrical component equals official UL recognition for that component.

And the recently introduced MDA3500 series 35 amp full wave bridges that caused such a stir among you awhile back are now recognized by UL (what else!?!).

Reason for stir? Superior performance at equal cost.

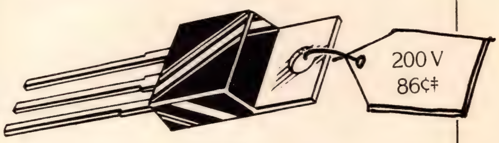
Reason for card? So you can more easily get UL APPROVAL on your equipment by designing in components already checked out for flammability, electrical shock, thermal characteristics, chemical analysis, etc., etc.

To refresh, the MDA3500 series is a 35 amp bridge family priced at 25 amp levels. Besides furnishing 10 extra current-handling amperes, it offers 100 extra amps of surge current protection. And super-efficient, 70-watt P_D. And low AQL. And low θ_{JC}. And fast turnaround.

And a price tag of just $2.35, 25-99, for a 200-volter.

Customers are ordering it by the thousands and competition is mumbling under its breath.

And all we wanted was a little recognition.



And now a new Triac, plastic, with 15 amp, 800 volt kick. Its glass passivation is just a sensation; its price tag sends studs up the crick.

That price tag runs about 30% less than for comparable studs — a bottom-line advantage that ought to make this very first of its TO-220 kind an irresistible choice for many commercial/industrial designs.

The 15 A(RMS) MAC15/15A is designed for full wave ac control in solid state relays, light dimmers, motor and heating controls and power supplies or

‡10,000 PCS.

wherever full-wave thyristors are needed.

Reliability? Coming right up in 150 A surge protection, all-diffused and glass-passivated junctions, gate cathode passivation, improved copper piece parts, void-free encapsulant, in-process and outgoing QC and reliability verification.

The small, rugged Thermowatt* package offers low thermal resistance, high-heat dissipation and durability.

Gate triggering is guaranteed in two or four modes.

Use it everywhere you need to cost-reduce comparable metal parts.

Get it from a supplier who knows triacs, reason and rhyme, all the time. Motorola.

The case of the pooped-out powertab

OR, GE whiz, man, your wattage is missing.

Don't take the rap for that nemesis of the honest engineer, that rapscallion of purloined performance — Skimpy Power Dissipation. It can kill you with a feeble 1.67 watts of P_D.

Turn to the only savior you have . . . Motorola's dynamic D40/41 Duowatt* plug-in replacements with **2 watts** of free-air power dissipation, and a better price.

Our powertab units eclipse theirs by 20% in power-handling and in the lowest θ_{JC} in the industry: 62.5°C/W for lower-junction stress and a real edge in reliability and long life.

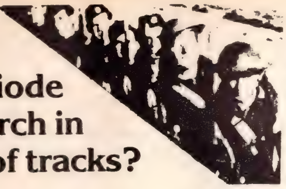
Plus, Duowatts offer second-generation epoxy molding with lower resistance to heat, higher resistance to moisture and greater strength.

Here's the run-down:

Series	Application	P_D — Watts	
		GE	Motorola
D40C	NPN Darlington	1.67	2
D40D/41D	NPN/PNP 30-75 V Hi-gain Ampl.	1.67	2
D40E/41E	NPN/PNP 30-85 V Hi-gain Ampl.	1.67	2
D40K/41K	NPN/PNP Darlingtons	1.67	2
D40N	NPN HV Ampl.	1.67	2
D40P	NPN HV/Hi-gain Ampl.	1.67	2

Motorola Duowatts solve the power problem. Elementary, Watson, elementary.

How does a tuning diode army march in one set of tracks?



Abruptly, of course.

The new MV210 is an abrupt junction varactor diode inherently capable of tracking and matching the capacitance of the one in front of it, and behind it, over the entire voltage range.

In the past, painstaking, expensive testing and matching was required when using more than one varactor diode in a tuning system, plus costly tuning circuit adjustment once you got it all together.

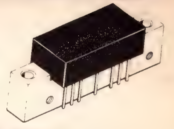
The '210 plastic TO-92 solves all that by requiring just one voltage level check. All the diodes that match each other at that level, will match at any other chosen voltage level in the spectrum.

It's also got 100 min Q at 100 MHz, controlled, uniform ratio of C_1C_{25}=3.4 min 3.7 max and a low 90¢ price.

Use the '210 in FM, TV, CB-VCO synthesizer control and general frequency control to count a better cadence and cut design and testing involvement.

Forward, march.

CATV's out of the bag



Motorola Modules Play Better!

Spec for spec, Motorola's new 17 and 34 dB CATV modules outplay anything else, even West Coast re-runs.

Same package, mind you, just better performance — like 35 channel instead of 32 guaranteeing low-distortion limits and a 7.0 db max noise figure tested at 300 MHz, not channel 13.

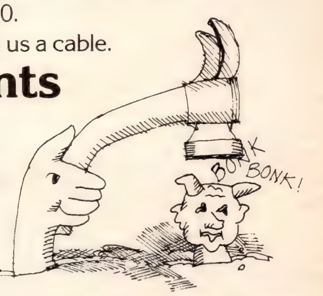
And if long term reliability's your major suit, they've got that too. This series incorporates a unique state-of-the-art transistor with emitter metal current densities and MTTF figures that challenge comparison. Tests on the geometry have accumulated over 750,000 operating hours at 90-100°C case. And we're still waiting for the first failure.

You don't have to design them into CATV. Any low-noise, low-distortion, flat-gain application from 40-300 MHz will do.

Just call and ask for the MHW594 & 5 and MHW580.

Or send us a cable.

Nail down voltage transients with unique crowbar IC

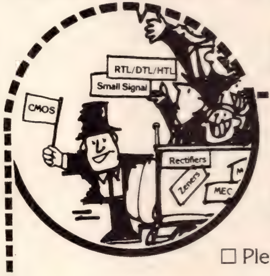


If nasty little gremlins run around in your circuit playing havoc with voltage limits, and your nerves, pin 'em to the wall with the MC3423.

This one-of-a-kind linear unit protects sensitives from transients or regulator failure. It senses overvoltage immediately and quickly crowbars, or short circuits, the supply forcing it into current limiting or opening the fuse or CB.

It's used with an external SCR, such as the new TO-220 25A 2N6504 capable of surge protection to 300A. Protection voltage threshold is adjustable and the circuit can be programmed for minimum duration of overvoltage condition before tripping. This feature prevents false tripping in noisy environments which would normally not harm the load.

It also offers additional output for use as OVP indication as an open-collector transistor when the OVP is activated. Just a buck-and-a-half, friends.



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☐ MV210 Tuning Diode
☐ MC3423 OVP Linear IC

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designed for the User, —logically.

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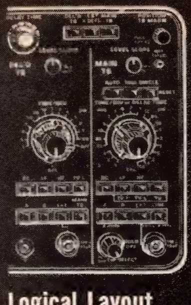

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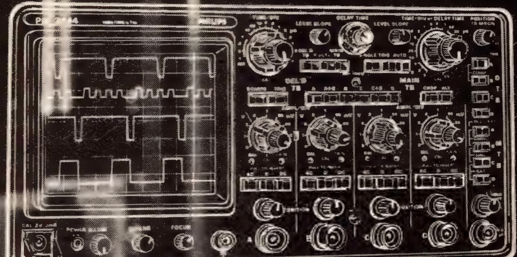

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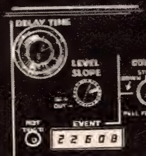

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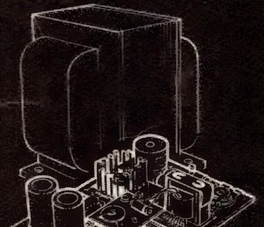

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LF355 (Single BIFET)	1	30	3	2.5	5
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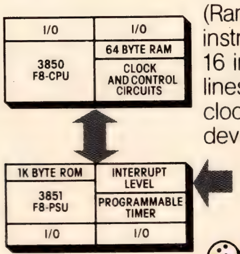

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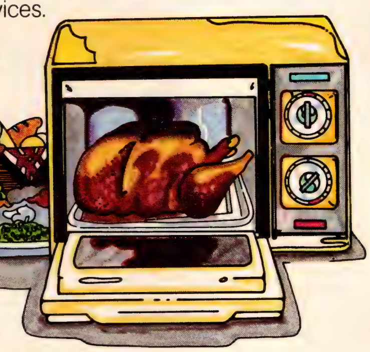

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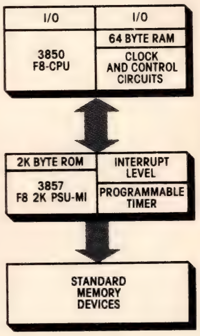
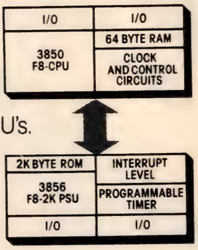


Double the program storage



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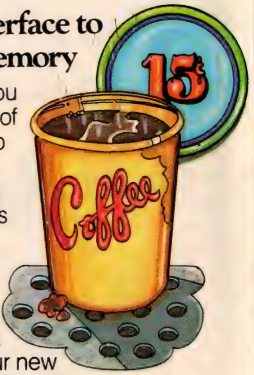

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Add vectored interrupts and memory-mapped I/O to 4-bit μP's

Has the somewhat limited I/O structure of 4-bit μP's constrained your designs? These "memory-expanding" schemes just might help.

Irving H. Thomae, Dartmouth College

The extremely low costs of the Intel 4004 and 4040 4-bit microprocessors have made them very popular as components of point-of-sale terminals, dedicated controllers, lab instruments, and consumer products. Unfortunately, the joint-addressing scheme for I/O and RAM provides only four bits for I/O port selection. In addition, memory addresses and port numbers are not encoded in the read and write commands which reference them, but instead must be designated in advance by the send-register-control (SRC) instruction—in most cases a 2-byte operation!

By adopting a pseudo-memory-mapped input structure **(Fig. 1a)** when using the 4008/4009 (or 4289) interface chips, you can expand the potential number of input ports to 256 while eliminating the byte-wasting "SRC" command.

Tri-state bus driver turns the trick

The following method depends on the fact that the branch-back-from-subroutine command (BBL) also loads the accumulator. Thus, for 16 ports or less, a single additional tri-state bus driver and a rearrangement of existing connections comprise the only hardware additions necessary.

How does this scheme work?

An unused page of program memory is assigned to I/O, with the chip-select for that page enabling a set of drivers connected to the 8-bit PROM return bus **(Fig. 1b)**.

The input multiplexer(s), customarily connected to the "I/O bus" pins of the 4009 or 4289, tie instead to the "OPA" (least significant) lines, with the code for "BBL" (1100) hard-wired to the portion of the bus driver that feeds the "OPR" (most significant) lines. Many systems will already contain one 4-line tri-state driver (DM 8093, 3216, etc.); new designs can use the Intel 8212, an 8-bit device. Thus the chip count for the basic system increases by, at most, one.

Now you can "jump" right into things

Programming for input operations now consists simply of a jump subroutine (JMS) to an address in the "virtual ROM," where the connections effectively simulate a one-byte subroutine. This subroutine has only the instruction "BBL x", with the input port supplying the "x" value. With appropriate decoding or multiplexing, each of up to 256 addresses can now represent a different 4-bit input port.

Fig. 2a compares the conventional method with this new routine. Notice how it reduces the input operation to a "subroutine call" to an address associated with the desired port. This arrangement works more conveniently with the 8-stack-level 4040 than with the 4-stack-level 4004.

As you evaluate this approach, keep in mind that only as much decoding is needed as the number of ports indicates. As examples; for a quantity of ports from 9 up to 16, you only have to decode four bits of address. Why? Because the hex "input-page" addresses 03, 13, 23,... F3 would all be interpreted as the address of port number 3. Similarly, a quantity of ports from 17 up to 32 requires decoding of five bits, which makes addresses 03 and 23, 13 and 33, etc., equivalent.

Will it work with 8-bit inputs? You bet!

With a slight increase in complexity, you can employ basically the same approach for up to 64 8-bit inputs. This method implements the 2-byte fetch-immediate instruction (FIM) that normally loads an "index-register pair" with an 8-bit constant taken from the second byte of the instruction. By hard-wiring a group of three program locations to return "FIM Pn," the data of interest, and "BBL," respectively, eight bits of data can be ingested from a source determined (as in the case above) by a subroutine address. Allocating a group of four addresses to each 8-bit

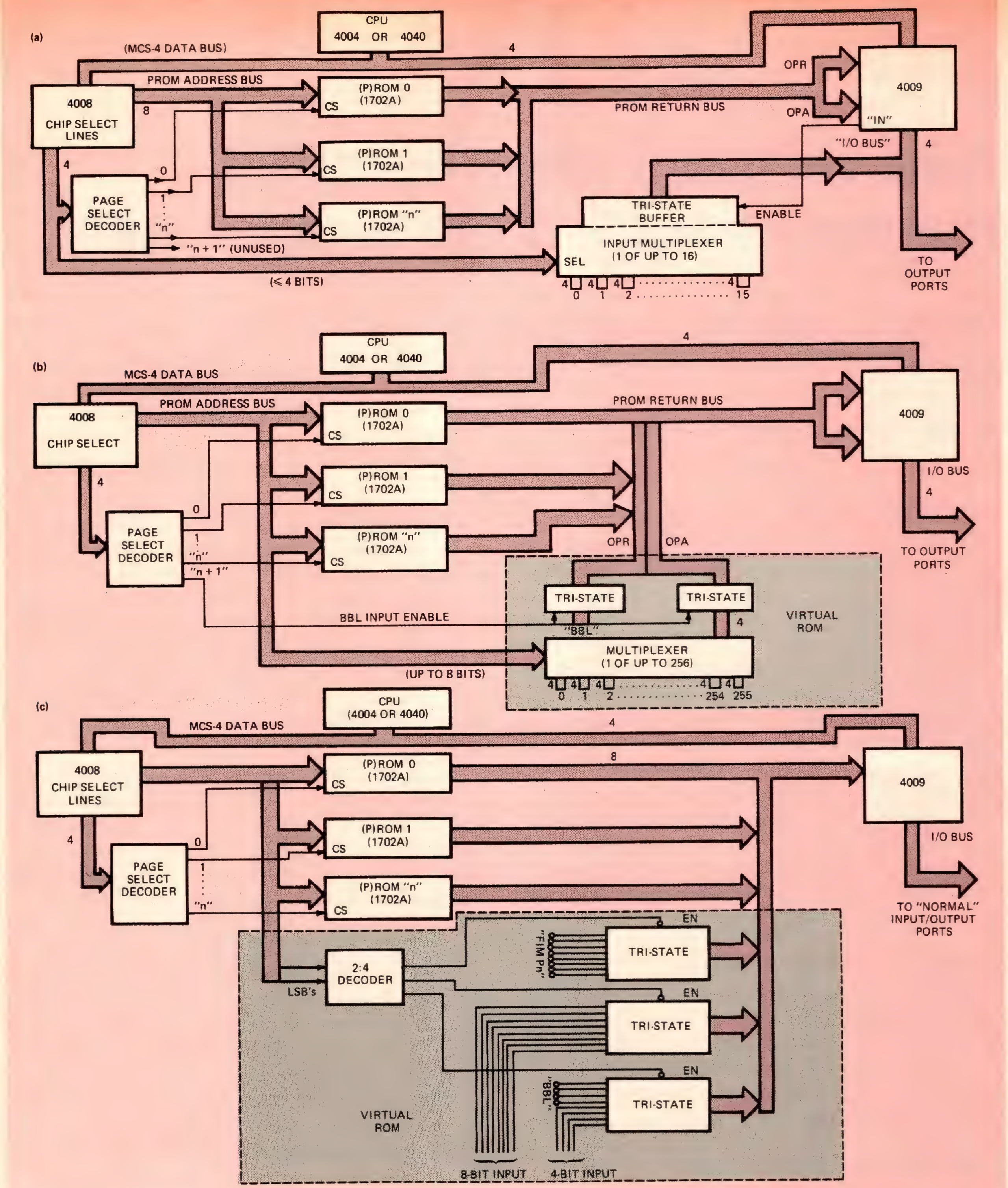


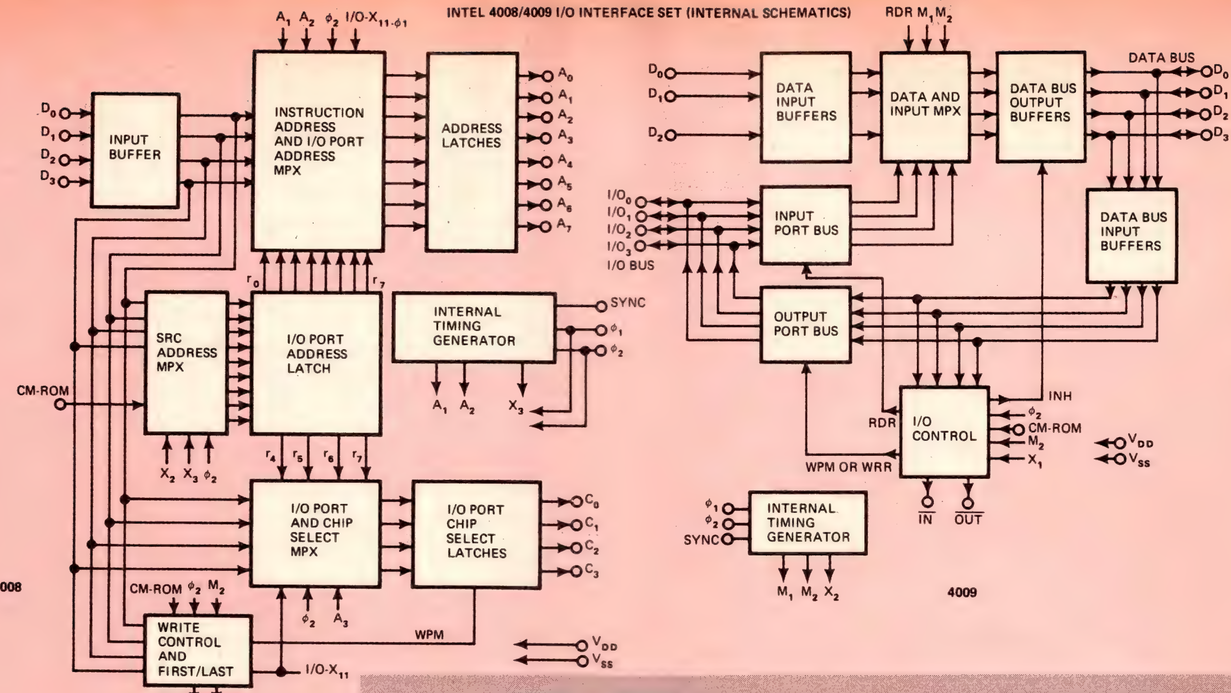
Fig. 1—A pseudo-memory-mapped I/O structure, suitable for 4-bit 4004/4040 Series µP's, is formed with only a few extra logic blocks. How? Compare the conventional system diagram of **a** with those of **b** and **c.** Notice how the 4-bit scheme of **b** reassigns an unused "page" of program memory to I/O while the chip select for that page enables a set of drivers on the PROM return bus. In **c,** the system is expanded to 8-bits.

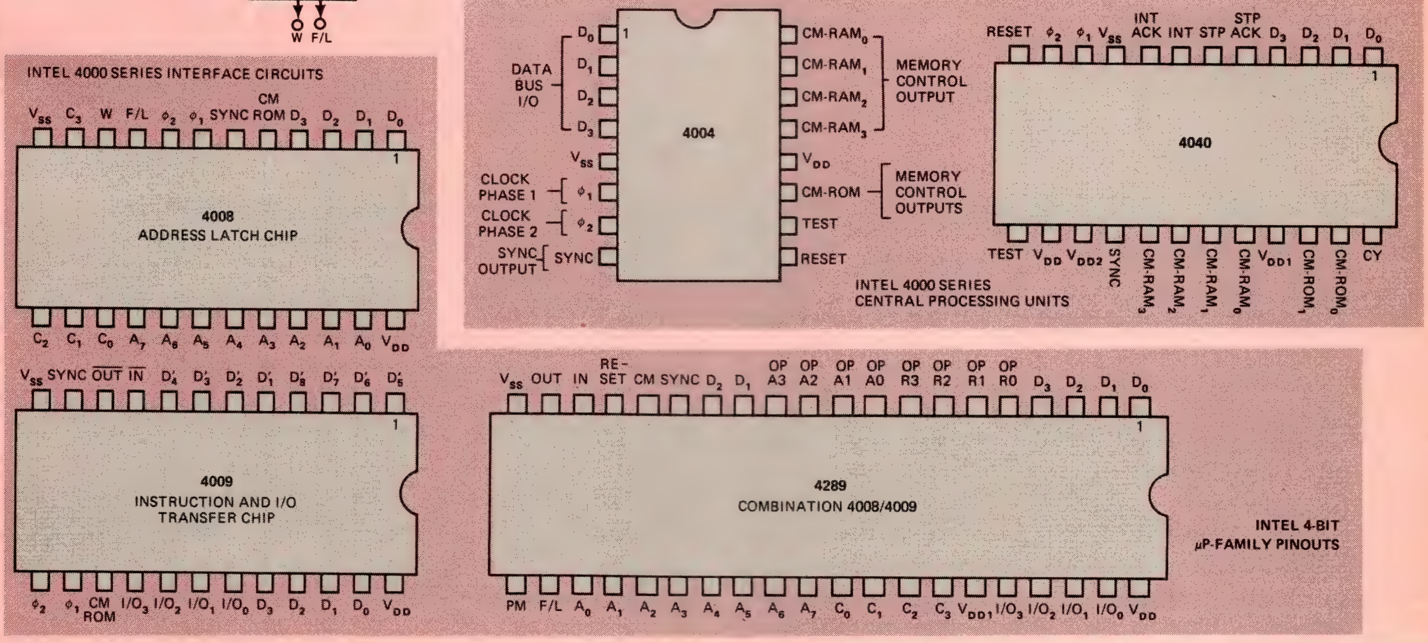
input routine **(Fig. 2b)** then greatly simplifies decoding. A decoder connected to the least significant two bits of the program address lines will cause this sequence of instruction codes to return from any set of locations beginning with 0 (modulo 4) **(Fig. 1c).** You must choose a particular index-register pair as the fixed destination for these 8-bit inputs, but that tends to be good programming practice in any case.

All of which leads to vectored interrupts

Once you've implemented the 8-bit input scheme described above, the indirect jump instruction "JIN" can be combined with this

INTEL 4008/4009 I/O INTERFACE SET (INTERNAL SCHEMATICS)




INTEL 4000 SERIES INTERFACE CIRCUITS
VSS C3 W F/L φ2 φ1 SYNC CM ROM D3 D2 D1 D0
1
4008
ADDRESS LATCH CHIP
C2 C1 C0 A7 A6 A5 A4 A3 A2 A1 A0 VDD
VSS SYNC OUT IN D'4 D'3 D'2 D'1 D'8 D'7 D'6 D'5
1
4009
INSTRUCTION AND I/O TRANSFER CHIP
φ2 φ1 CM ROM I/O3 I/O2 I/O1 I/O0 D3 D2 D1 D0 VDD
DATA BUS I/O
D0 D1 D2 D3
VSS
CLOCK PHASE 1 φ1
CLOCK PHASE 2 φ2
SYNC OUTPUT SYNC
4004
CM-RAM0 CM-RAM1 CM-RAM2 CM-RAM3
MEMORY CONTROL OUTPUT
VDD
CM-ROM
MEMORY CONTROL OUTPUTS
TEST
RESET
RESET φ2 φ1 VSS INT ACK INT STP STP ACK D3 D2 D1 D0
1
4040
TEST VDD VDD2 SYNC CM-RAM3 CM-RAM2 CM-RAM1 CM-RAM0 VDD1 CM-ROM1 CM-ROM0 CY
INTEL 4000 SERIES CENTRAL PROCESSING UNITS
VSS OUT IN RE-SET CM SYNC D2 D1 OP A3 OP A2 OP A1 OP A0 OP R3 OP R2 OP R1 OP R0 D3 D2 D1 D0
1
4289
COMBINATION 4008/4009
PM F/L A0 A1 A2 A3 A4 A5 A6 A7 C0 C1 C2 C3 VDD1 I/O3 I/O2 I/O1 I/O0 VDD

INTEL 4-BIT µP-FAMILY PINOUTS

INTEL 4004/4040 BASIC INSTRUCTION SET

MNEMONIC	DESCRIPTION OF OPERATION
NOP	NO OPERATION
JCN	JUMP TO ROM ADDRESS $A_2A_2A_2A_2$, $A_1A_1A_1A_1$ [WITHIN THE SAME ROM THAT CONTAINS THIS JCN INSTRUCTION] IF CONDITION $C_1C_2C_3C_4$ IS TRUE, OTHERWISE SKIP (GO TO THE NEXT INSTRUCTION IN SEQUENCE)
FIM	FETCH IMMEDIATE (DIRECT) RROM ROM DATA D_2, D_1 TO INDEX REGISTER PAIR LOCATION R R R.
SRC	SEND REGISTER CONTROL. SEND THE ADDRESS (CONTENTS OF INDEX REGISTER PAIR R R R) TO ROM AND RAM AT X_2 AND X_3 TIME IN THE INSTRUCTION CYCLE.
FIN	FETCH INDIRECT FROM ROM. SEND CONTENTS OF INDEX REGISTER PAIR LOCATION 0 OUT AS AN ADDRESS. DATA FETCHED IS PLACED INTO REGISTER PAIR LOCATION R R R .
JIN	JUMP INDIRECT. SEND CONTENTS OF REGISTER PAIR R R R OUT AS AN ADDRESS AT A_1 AND A_2 TIME IN THE INSTRUCTION CYCLE.
JUN	JUMP UNCONDITIONAL TO ROM ADDRESS A_3, A_2, A_1.
JMS	JUMP TO SUBROUTINE ROM ADDRESS A_3, A_2, A_1, SAVE OLD ADDRESS. (UP 1 LEVEL IN STACK.)
INC	INCREMENT CONTENTS OF REGISTER R R R R .
ISZ	INCREMENT CONTENTS OF REGISTER R R R R. GO TO ROM ADDRESS A_2, A_1 (WITHIN THE SAME ROM THAT CONTAINS THIS ISZ INSTRUCTION) IF RESULT $\neq 0$, OTHERWISE SKIP (GO TO THE NEXT INSTRUCTION IN SEQUENCE)
ADD	ADD CONTENTS OF REGISTER R R R R TO ACCUMULATOR WITH CARRY
SUB	SUBTRACT CONTENTS OF REGISTER R R R R TO ACCUMULATOR WITH BORROW.
LD	LOAD CONTENTS OF REGISTER R R R R TO ACCUMULATOR.
XCH	EXCHANGE CONTENTS OF INDEX REGISTER R R R R AND ACCUMULATOR.
BBL	BRANCH BACK (DOWN 1 LEVEL IN STACK) AND LOAD DATA D D D D TO ACCUMULATOR.
LDM	LOAD DATA D D D D TO ACCUMULATOR.

What happens during a SRC instruction?

Should you be unfamiliar with the send-register-control command referenced in this article, here's a chronological sequence of its operation.

1. The SRC register accepts and stores the 8-bit I/O address.
2. SRC register contents transfer to address lines A_0-A_7 and to chip-select lines C_0-C_3.
3. The specified I/O port is selected by decoding the chip-select lines.
4. IN/OUT lines indicate the direction of data transfer.

The 4-bit family at one glance

For your convenience, we've printed the pin-outs, the internal schematics and an abbreviated instruction set of Intel 4004/4040 µC components referred to in this article. For more detailed information call or write the manufacturers directly.

```
(a) TO ACCESS INPUT PORT 03
    [ASSUMING PAGE 7 USED FOR INPUT]

    CONVENTIONAL METHOD
    FIM P6 30
    SRC P6
    RDR
    [4 BYTES 4 CYCLES]

    NEW METHOD
    JMS 703 ← MAIN PROGRAM JUMP COMMAND
    703: BBL (X) ← VIRTUAL ROM
    [2 BYTES, 3 CYCLES]

(b) XXXX JMS 905 ← MAIN PROGRAM
    0904 NOP
    0905 FIM P(N) ← VIRTUAL ROM
    0906 [THIS ADDRESS ENABLES THE DATA]
    0907 BBL

(c) 0003 --- ← INTERRUPT ROUTINE BEGINS
         ---
         ---
         --- ← SAVE CURRENT MACHINE STATE
    XXXX JMS 701
    YYYY JIN P0
    0010 JUN DEV0
    0012 JUN DEV1
    0014 JUN DEV2
    0016 JUN DEV3
    ETC. ETC. ETC.
    0700 NOP
    0701 FIM P0
    0702 [ENABLES INTERRUPT VECTOR ONTO
           PROM RETURN BUS]
    0703 BBL
```

Fig. 2—Clever "hard and soft" programming techniques "virtually" eliminate the memory-limiting "kluginess" of the 4004/4040's I/O operations. In **a,** a head-to-head comparison between conventional and memory-mapped approaches gives proof of this method's byte-saving features. The routine in **b** demonstrates that 8-bit decoding need not be complicated while **c** furnishes a way to generate vectored interrupts.

scheme to provide a quite reasonable vectored-interrupt routine. The "JIN Pn" instruction transfers control to a location in the current program page specified by the contents of the index-register pair named. If each interrupting device furnishes a unique 8-bit code divisible by two, the interrupt routine outlined in **Fig. 2c** becomes possible. Note that the scheme permits only even-valued interrupt vectors, since each unconditional jump takes two bytes. Nevertheless, room theoretically exists for on the order of 120 different vectors.

Within program loops, and in multilayered lookup procedures wherein the value of one input dictates the choice of the next input, the contents of an index-register pair should select the input. (The SRC command does this, of course, for one of 16 4-bit inputs.) You can extend this capability to a choice of as many as 254 8-bit inputs by implementing the fetch-indirect instruction (FIN Pn)—normally used for table lookup. Index-register pair 0 furnishes the lookup vector, and eight bits of data are loaded (from within the current page of program) into register pair n. Applying the same principles as before, a virtual ROM can be created whose last two locations will return codes "FIN Pn" and "BBL y" for example. For flexibility, you can assign a few more locations to provide several alternative FIN instructions, each specifying a different Pn. The FIN operand is derived from the address itself to provide all possible FIN instructions in one group of 16 simulated bytes of code.

Need more inputs? It gets complicated!

To access a full set of 256 inputs, the hardware implementation involves more than the schemes previously described: Since FIN is a 2-cycle instruction, with data input occurring during M1 and M2 of the <u>second</u> cycle, the ROM address lines out of the 4008 (or 4289) select the input (as dictated by the contents of P0). Therefore, <u>that</u> input should be gated onto the PROM return lines. If the selection codes for 8-bit inputs overlap any hard-wired addresses in the page of virtual ROM used for this input mode, you must set a one-bit latch upon detecting an access to the "FIN." In this manner <u>inputs</u>, rather than wired codes, drive the ROM return on the following cycle.

So you want memory-mapped 4-bit output, eh!

This too will follow the "dummy subroutine" approach, now of the form "WRR," "BBL". Though the output latches feed from the "I/O bus" of the 4009 or 4289, the number of possible ports can increase to 128 if the address of the "subroutine" drives the decoder, instead of the SRC output. Since the address lines of the 4289 actually carry the SRC address during X3 when the I/O bus presents the output data to the latches, you should latch those lines during A3, M1 or M2, using CM-ROM output line. Either the (Intel) 8212 or the (RCA) CD4043AE makes a suitable latch. □

Author's biography

Irving H. Thomae is an Assistant Professor of Engineering at Dartmouth's Thayer School of Engineering, Hanover, NH, where he conducts research and teaches courses in digital design, μP applications, and specialized computer architectures. Holder of BS and PhD degrees from M.I.T., Irving is an active member of IEEE, ASEE, OSA and AAAS, and enjoys constructing scale-model railroads and backpacking in his spare time.

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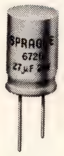

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- Bus-bar mounting
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Construction	Rolled-Section	Rolled-Section	Rolled-Section	Stacked-foil
Terminal Configuration	2 terminals, wire pins	4 terminals, wire leads	2 terminals, low or high female threaded	2 terminals, strip-line, female threaded
Case Size Range (D. x L.)	.326″ x .505″ to 1.000″ x 1.625″	.750″ x 1.625″ to 1.000″ x 3.625″	1.375″ x 2.125″ to 1.375″ x 5.625″	1.375″ x 2.125″ to 3.000″ x 5.625″
Operating Temperature Range	—55°C to +105°C	—55°C to +105°C	—55°C to +85°C	—40°C to +85°C
WVDC Range	6.3 to 100	5 to 200	5 to 55	6 to 50
Capacitance (Range (µF)	4.7 to 6800	50 to 16,000	2,800 to 67,000	470 to 100,000
Capacitance Tolerance	—10, +100%	thru 50 V: —10, +75% over 50 V: —10, +50%	±20%	—0, +100%
Max. Inductance (@ 1 MHz & within .125″ of capacitor)	20 nH	2 nH	20 nH	2 nH
	1200 µF @ 6.3 WVDC	16,000 µF @ 5 WVDC	67,000 µF @ 5 WVDC	100,000 µF @ 6 WVDC
Max. ESR (@ 25°C and 120 Hz)	.11 ohm	.022 ohm	.004 ohm	.0015 ohm
RMS Ripple Current (@ 85°C)	2.61 A @ 100 kHz	7.00 A @ 10 kHz	19.5 A @ 20 kHz	54.6 A @ 1 kHz
Max. Impedance (@ 25°C)	.06Ω @ 100 kHz	.017Ω @ 10 kHz	.010Ω @ 10-40 kHz	.001 Ω @ 10 kHz
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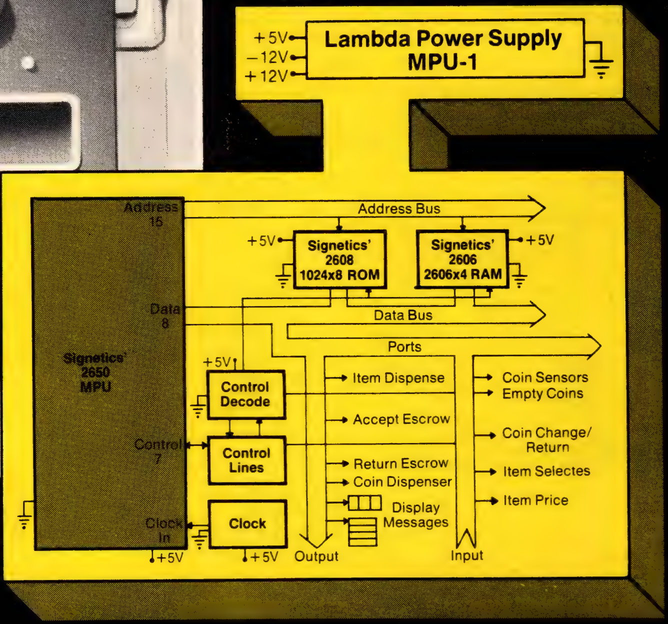

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This 30-ppm scale proves that analog designs aren't dead yet

Electronics does not live by μP's alone. This analog instrument achieves 0.02% absolute accuracy, yet never needs adjustment.

James Williams, Massachusetts Institute of Technology

Body weight is a critical indicator in human nutritional studies. In fact, the ability to repeatedly resolve small weight changes is often the limiting factor in those investigations involving sweat losses and other metabolic functions. A very careful nutritional experiment conducted by the M.I.T. Clinical Research Center required an instrument that would repeatedly resolve 0.01 lb out of 300.00 lbs. F.S. That's 30 parts per million—about one doughnut bite in a 300-lb subject! Additionally, the instrument had to be portable, never require calibration or adjustment, and have an absolute accuracy within 0.02%.

Perhaps the most notable feature of the instrument is that, despite its ultra-high performance, its design used only readily available components and not one single custom item. By combining judicious component selection with careful engineering, a state-of-the-art instrument moved from conception to finished prototype in a very short time.

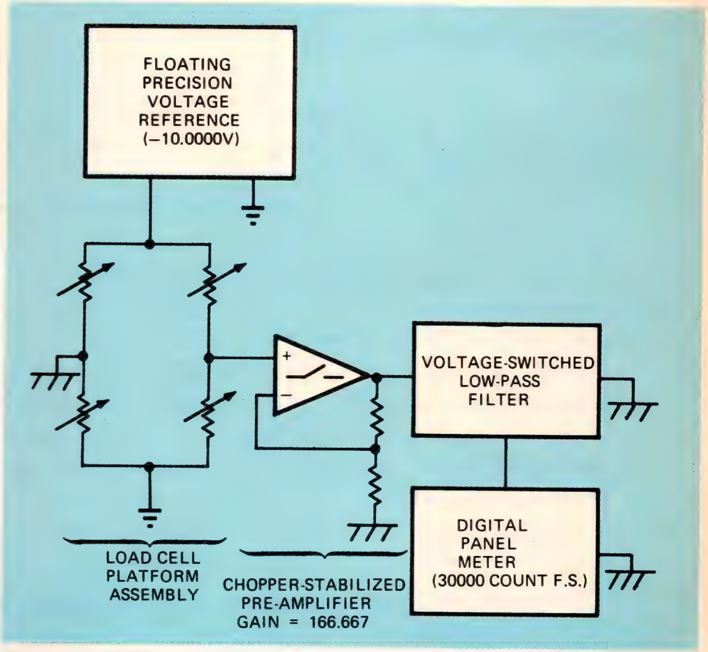
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Fig. 1—Straightforward approach used in the scale can be seen from this block diagram. What can't be seen is the attention to detail required to obtain the outstanding performance.

Eliminate nonessential error sources

Basically, the metabolic scale combines precision strain gauges and low-drift electronics **(Fig. 1).** The 10×12×5-in. platform assembly contains four bonded strain gauges distributed symmetrically. Together with linearizing and offset-correcting resistors, these strain gauges form a bridge network. When a patient steps on the platform, the electronics amplifies and processes the bridge signals, producing a voltage linearly proportional to weight that is displayed on a DPM.

Ed Note: True or false: Analog circuits continually need adjustment or must use custom components to achieve precision results? False! While it's true that analog designs have definite limitations—as indeed do digital ones—an inventive designer can overcome many obstacles and produce outstanding results. We hope that the following example of analog achievement will inspire designers to even greater triumphs.

A precision voltage reference excites the strain gauge bridge. This supply derives its stability from an aged, current-trimmed, temperature-compensated zener diode. Because the reference supply is fully floated from system ground, the output of the load-cell bridge appears as a single-ended, rather than a differential signal. This factor is significant and deliberate, in that it eliminates all common-mode voltage error possibilities and allows the use of a high-stability chopper-stabilized amplifier as a pre-amplifier.

The pre-amplifier is required to boost the load-cell signal up to levels that can be easily processed. With 10V excitation the strain-gauge

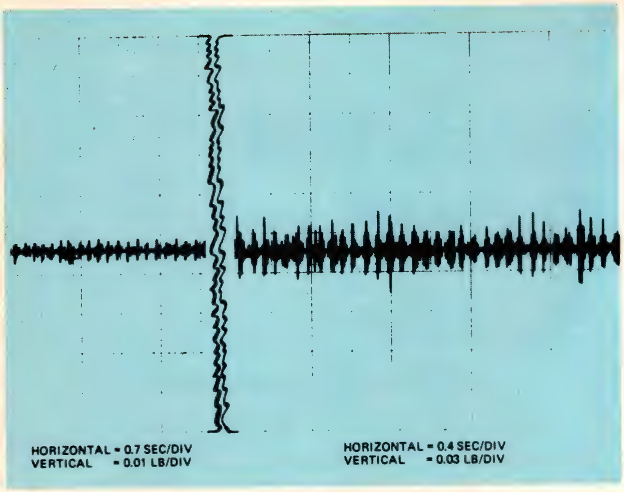


Fig. 2—"Weighing" a heartbeat is possible due to the scale's 0.01-lb resolution. These ac-coupled chart recordings were taken from the output of A_3. On the left is a normal heartbeat; on the right, the rhythm after a short, but fast, run.

bridge yields only 18 mV F.S. Thus, one least significant digit (0.01 lb) is only 600 nV at the transducer output.

Although the clinical operating temperature range is quite narrow (20 to 30°C), overall system accuracy requirements dictate a pre-amplifier that drifts 120 nV/°C, max.—200× better than a 741-type op amp. Chopper stabilization techniques combined with stable feedback resistors, attention to grounding and avoidance of thermal EMF's afford this performance. The signal, once amplified, must be filtered. Without filtering, small accelerations in the form of body motion and even heartbeat will cause jitter in the display **(Fig. 2).** While a simple R-C low-pass filter can provide the necessary smoothing, its long time constant means that the scale will require minutes to settle to five decimal places on the readout. The filter used avoids this problem by switching its time constant from short to long when it has acquired almost 100% of the pre-amplifier's output. The signal from the filter then drives the digital panel meter which provides a 300.00-lb F.S. display.

Achieve precision by attention to details

As previously mentioned, the 1N829 temperature-compensated zener is the key to the high-stability reference supply **(Fig. 3).** The zener owes its very low drift (typically 5 ppm/°C at 6.2V and 7.5 mA) to junctions with opposing temperature coefficients. However, any individual diode has its own "ideal" current at which the two junctions' temperature coefficients very precisely cancel out. Once this current has been experimentally established, drift performance of 0.1 ppm/°C can be achieved.

Our method for establishing the true zero-drift point involves first running the manufacturer's recommended 7.5 mA through the diode under test, placing it in a 50°C oven, and reading its voltage. We then take another reading at 0°C, noting the difference (drift). Changing the diode current, we repeat the experiment. Iterating this procedure yields the current that produces the least drift—the "ideal" current.

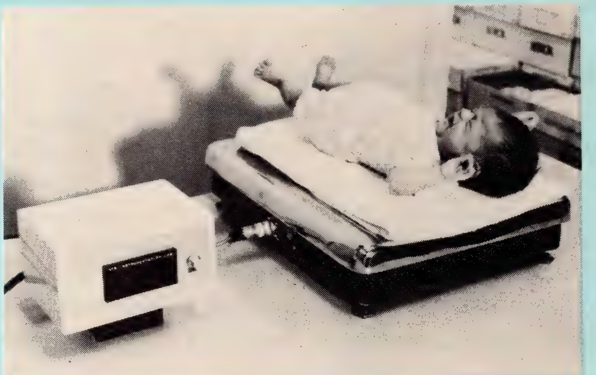
To age the diode we burn it in at the ideal current for 1000 hrs. Finally, we repeat the

A vast improvement over conventional instruments

Body-weight change is an extremely important parameter of body composition in clinical studies, particularly those concerned with the estimation of protein and energy utilization and the assessment of human requirements. Because the scale described in this article can be transported and, at the same time, offers improved sensitivity, accuracy and automatic data recording, it should prove extremely valuable in metabolic research.

For example, this scale permits precise, frequent monitoring of body-weight changes over short as well as long-term periods, important measurements in studies of energy balance. The device also can measure miniscule, previously undetectable water losses.

Since the scale employs body-motion filtering, it is ideal for weighing restless infants and young children. Normally, motion on a scale makes stable readings difficult, if not impossible, to obtain.



Besides providing an unambiguous, ultrahigh precision readout, the scale eliminates human-factor errors since it needs no adjustment, can be easily interfaced to computers and other circuitry, and can withstand overload and rough handling.

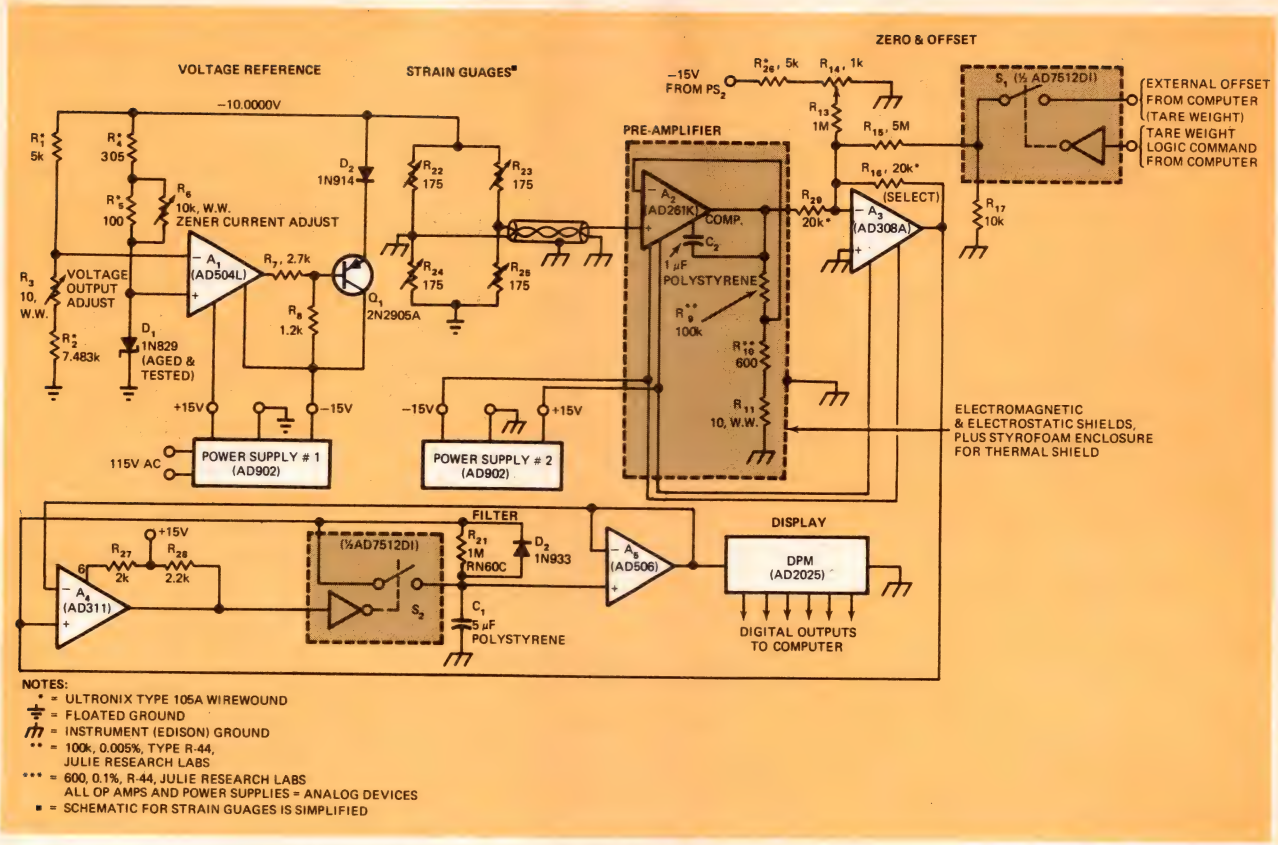


Fig. 3—Only standard, readily available components are used in the scale's circuitry. For proper operation, at least $10^8\Omega$ of insulation must exist between the common terminals of the power supplies.

temperature tests to fine-tune the final minimum drift current.

The aged and tested reference diode is installed in a bridge circuit buffered by a low-drift amplifier (A_1 in **Fig. 3).** The zener's potential biases A_1's positive input, while R_1, R_2 and R_3 provide the precise feedback necessary to obtain -10.0000V at the op amp's output. Note that the zener constant current is "bootstrapped" from the circuit's output. R_6 adjusts this current.

Since the strain-guage bridge presents a 200Ω load, Q_1 is included inside the feedback loop to provide current-driving capability. D_2 and R_8 guarantee that the circuit will "start up" correctly, while also ensuring that the reference diode can never become reverse-biased under any conditions. (Reverse biasing of reference diodes for even a few msec can introduce long term low-level drifts.)

The low temperature drifts of the D_1, A_1 and the wirewound resistors produce a -10.0000V reference supply with a total drift of only 0.25 ppm/°C. Because this is 150× the required system stability, reference drift effectively drops out of the error budget.

Noninverting chopper serves as pre-amp

Load-cell manufacturers offer the strain-guage bridge, its associated calibration resistors and the platform as a pre-trimmed assembly. Electrically, it can be modeled as a bridge of four 175Ω strain-dependent resistors. Because of these low impedances, the bridge supply can be floated from instrument ground without introducing serious pick-up noise into the bridge output.

In this circuit, pre-amp A_2 must extract a 600-nV signal (least significant digit) from a 5V dc level. Thus, a precision amplifier with low noise, <120-nV/°C drift and 140-dB CMR is required. Unfortunately, no instrumentation amplifier with such a combination of specifications exists—even the best differential instrumentation amplifiers offer only 250-nV/°C T.C.'s, 2-μV/day drifts and 120-dB CMR's. Therefore, to achieve the desired performance you must use a single-ended, noninverting chopper-stabilized amplifier such as the Analog Devices' 261K (100 nV/°C over 0 to 70°C with almost negligible time drift). This approach has one major trade-off, though: Because one leg of the bridge is grounded, the instrument cannot take a ratiometric measurement; i.e., the bridge and the panel meter require separate voltage references.

Observe from **Fig. 3** that R_9, R_{10} and R_{11} determine the pre-amplifier's gain. These components are of wirewound construction to obtain

Make sure that you are on solid ground

Proper grounding is critical to this circuit. Separate ground returns are required for each ground path, and all ground returns should be terminated at a single point at each power-supply common.

The power supplies used are standard modular types (Analog Devices Model 902). We mounted them outside the unventilated readout box to minimize heat rise and to prevent the transformer magnetics from influencing the pre-amplifier. Because one of the supplies floats, note that at least $10^8\Omega$ of insulation should exist between the ground terminals of the two supplies. The 902's are more than adequate in this respect.

the required stability. The op amp and its associated components should be both electrostatically and electromagnetically shielded from other circuitry, and careful attention must be paid to proper grounding (*see box*). We also recommend that you use low thermal noise solder for all connections. Finally, we advise wrapping the entire pre-amplifier assembly in styrofoam to provide a nearly isothermal enviroment.

The output of the pre-amplifier feeds a unity-gain inverting amplifier that sums in the system "zero" adjustment as well as externally generated "tare" signals. Note that R_{11} serves to trim the overall gain of both A_2 and A_3 to 166.667. This scales a 600-nV LSB (0.01 lb) to equal 100 μV at A_3's output, so that 300 lbs. F.S. equals 3.0000V to the DPM.

For fast settling, use a 2-step filter

For the signal from A_3 to be usable, filtering is absolutely necessary. The instrument is so sensitive that any body motion or floor vibration will mask true readings. Experimentation revealed that a simple 0.2-Hz R-C low-pass filter would provide adequate averaging. Unfortunately, this filter also would require almost 100 sec to settle out to the point where it no longer affected the system's accuracy. Clearly this time delay was unacceptable.

We considered using active and/or high-order filters to address this problem, but discarded them as being unnecessarily complex. Our final solution was to modify the basic R-C low-pass filter to incorporate a controllable time constant.

With no weight on the scale, the output of A_3 is zero, so no drop exists across R_{21} and A_5's output is also zero. Normally the output of comparator A_4 under these conditions would be indeterminate. However, the unorthodox use of the offset null adjustment (pin 6 connected to +15V through 2k) effectively "bends up" A_4's front end by introducing approximately 15 mV of offset. Therefore the amplifier's output saturates negative under no-weight conditions.

Placing a weight on the scale causes the output of A_3 to rise much faster than the voltage across C_1, so A_4's output goes positive, closing CMOS switch S_2. C_1 now charges quickly toward A_3's output voltage. When C_1's voltage rises to within 15 mV of A_3's output, A_4 switches its output negative and shuts off S_2. C_1 now charges to its final value through R_{21}. Amplifier A_5, a low-drift FET op amp, buffers C_1 and drives the DPM.

At the completion of the weighing process, removal of the weight causes A_3's output to drop to zero. In turn, D_3, a low foward-drop germanium diode, becomes forward-biased, providing a low-impedance path that rapidly discharges C_1. This ensures that the scale is quickly ready for the next measurement. ☐

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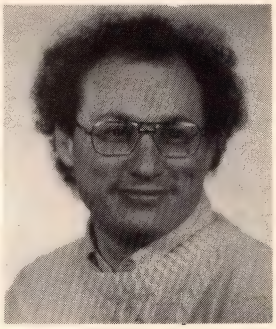
Author's biography



Jim Williams, a senior engineer in the instrumentation laboratory of M.I.T.'s Department of Nutrition and Food Science, designs and develops experimental bio-medical instrumentation. He received his BS in psychology at Wayne State Univ., holds three patents, and is a consultant to industry in several companies including Consultek, a Wellesley, MA consulting firm. Jim lists among his many hobbies sculpture, travel, art, skiing, tennis and collecting antique scientific instruments.

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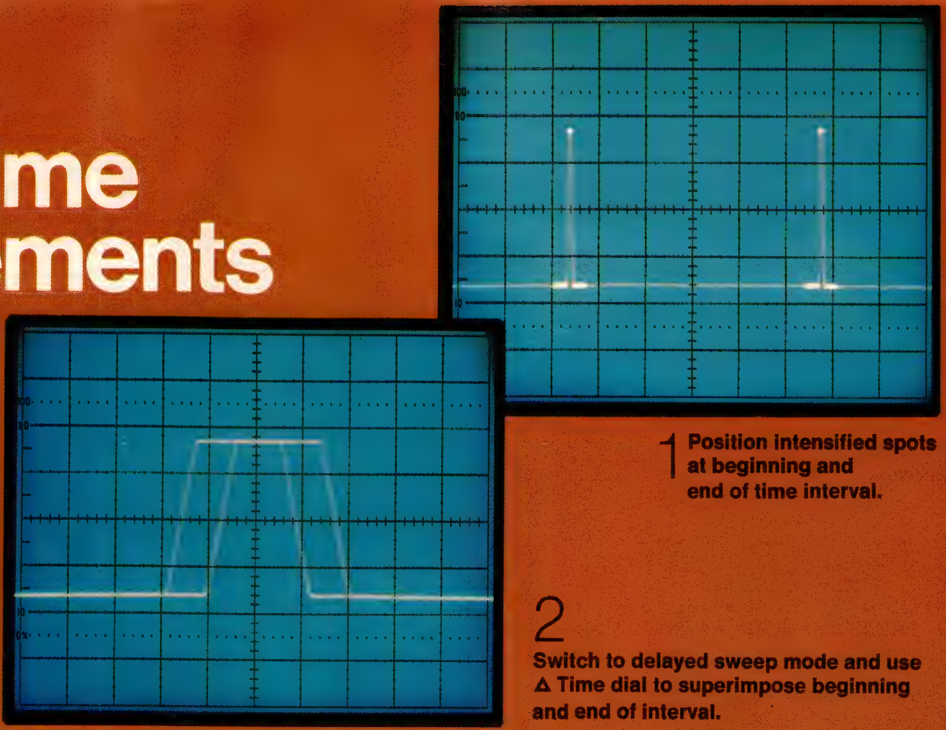

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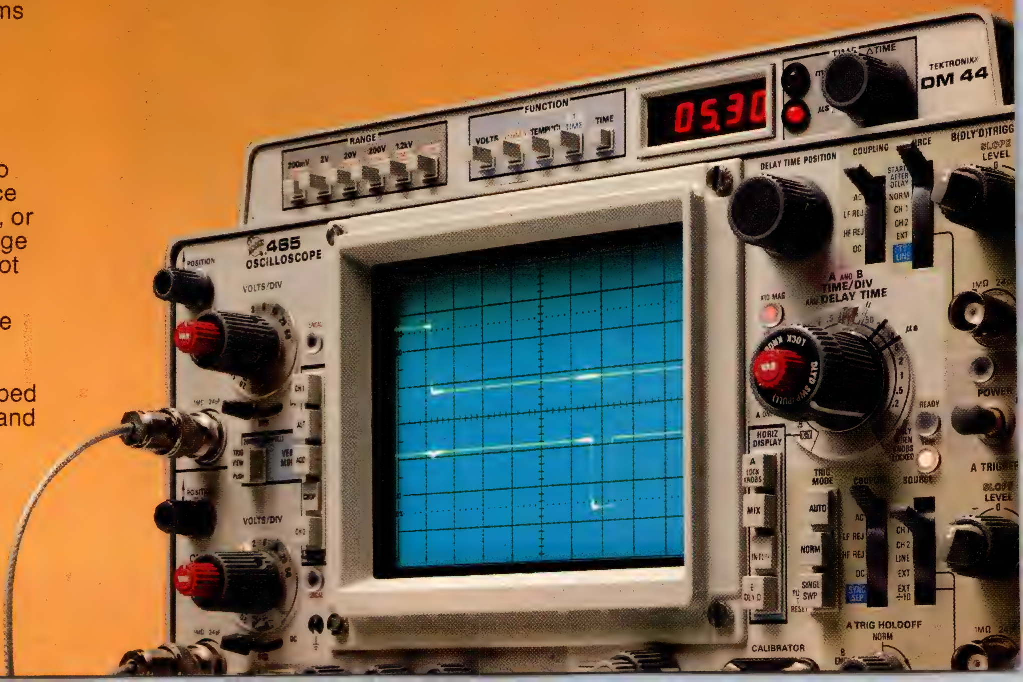

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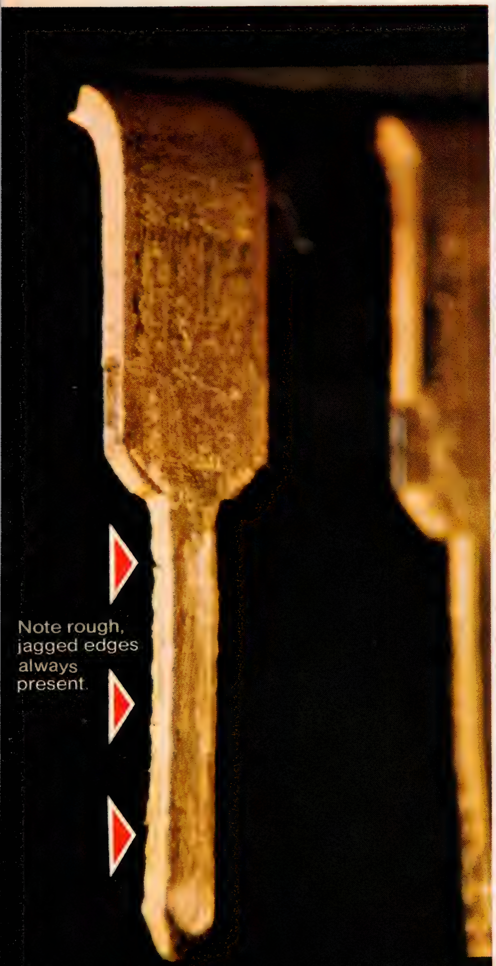
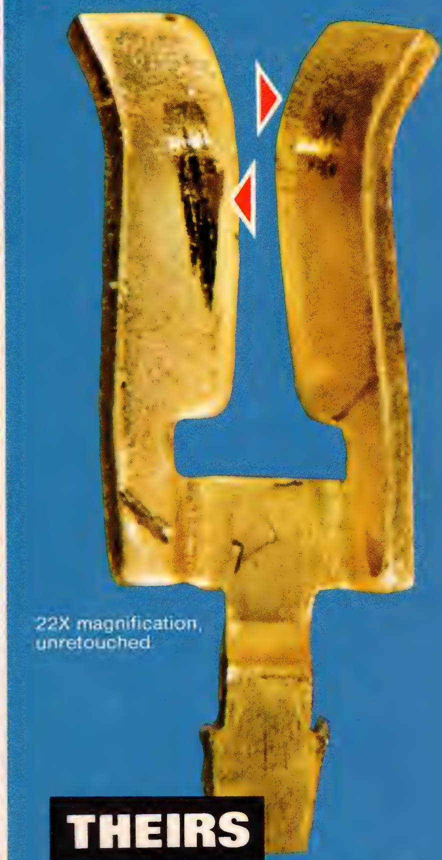


Note rough, jagged edges always present.

Your IC lead frames look like this at 30X enlargement (unretouched). Because they are punched out of metal, the edges are rough, jagged and irregular. In contrast, the flat sides of the lead frame are smooth, even and perfectly plated.

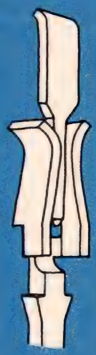
Arrows indicate scars and abrasions made by rough edge of lead frame.



22X magnification, unretouched.

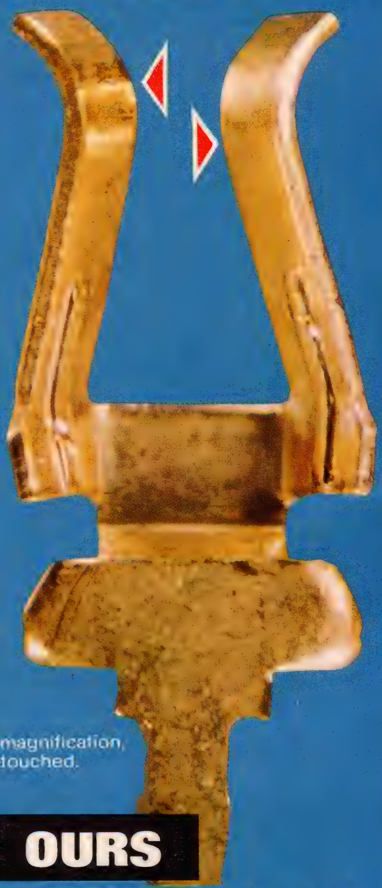
THEIRS

An ordinary edge-bearing socket contact after 5 insertions of DIP lead frame. Contact has been spread apart to show inside faces of contact. Notice how the contact has scars and abrasions from *rough, irregular edge of IC lead frame*. Electrical contact is degraded and resistance is increased. Reliability is obviously reduced.



Lead frame in place in an ordinary edge-bearing contact.

Arrows indicate contact surface still smooth, clean, free from abrasions.



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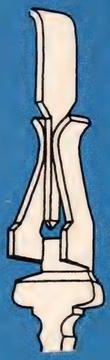
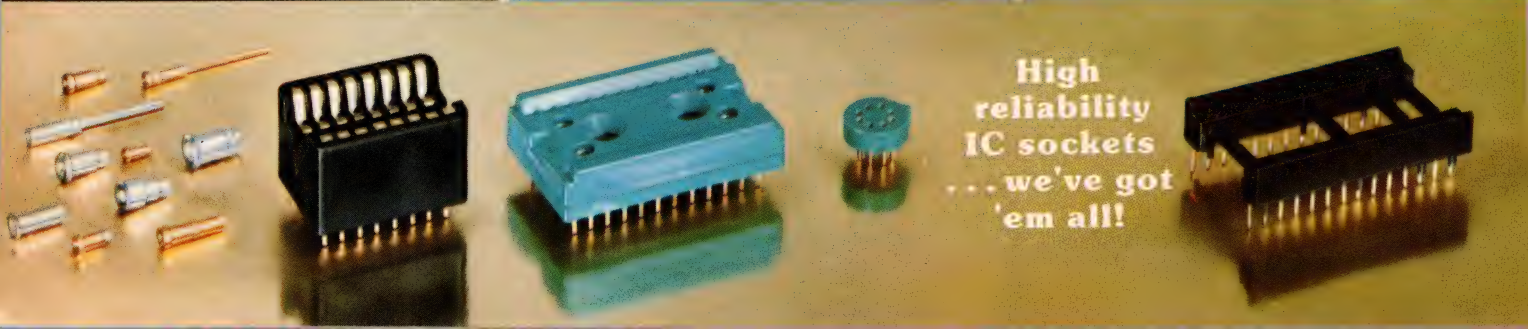
OURS

ROBINSON-NUGENT "side-wipe" socket contact after 5 insertions of DIP lead frame. Contact has been spread apart to show inside faces of contact. See how the RN contact—because it mates with the *smooth, flat side of the IC lead frame*—retains its surface integrity. This 100% greater lead frame contact results in continued high reliability.



Lead frame in place in RN "side-wipe" contact.



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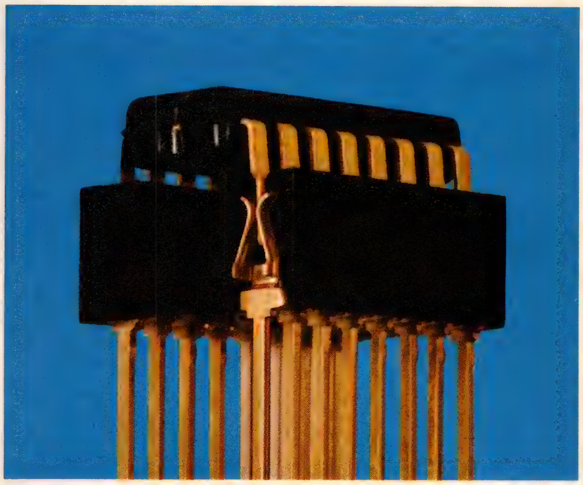

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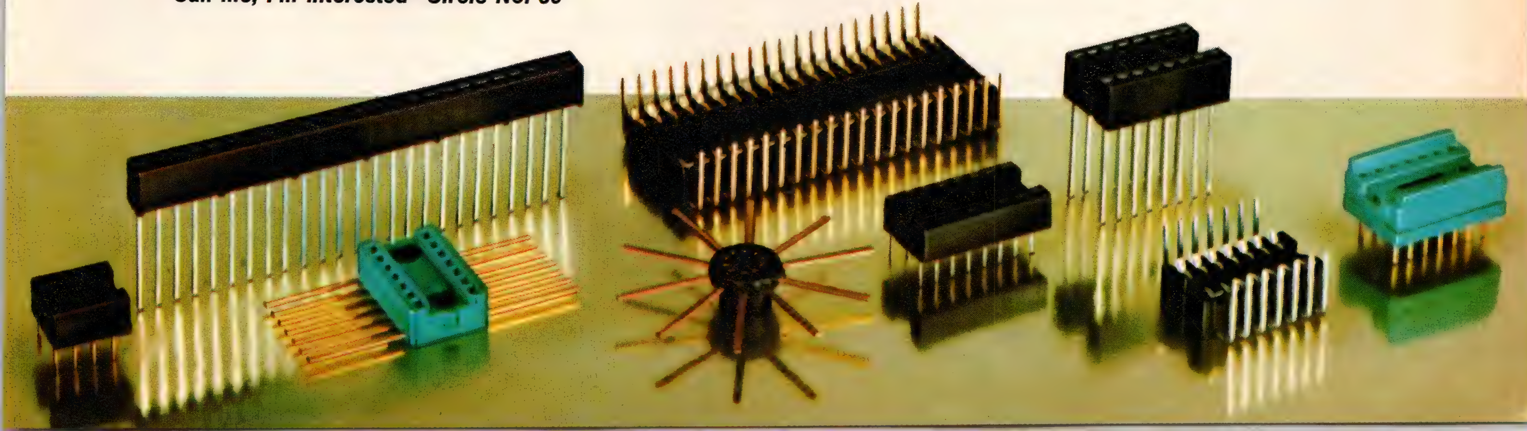

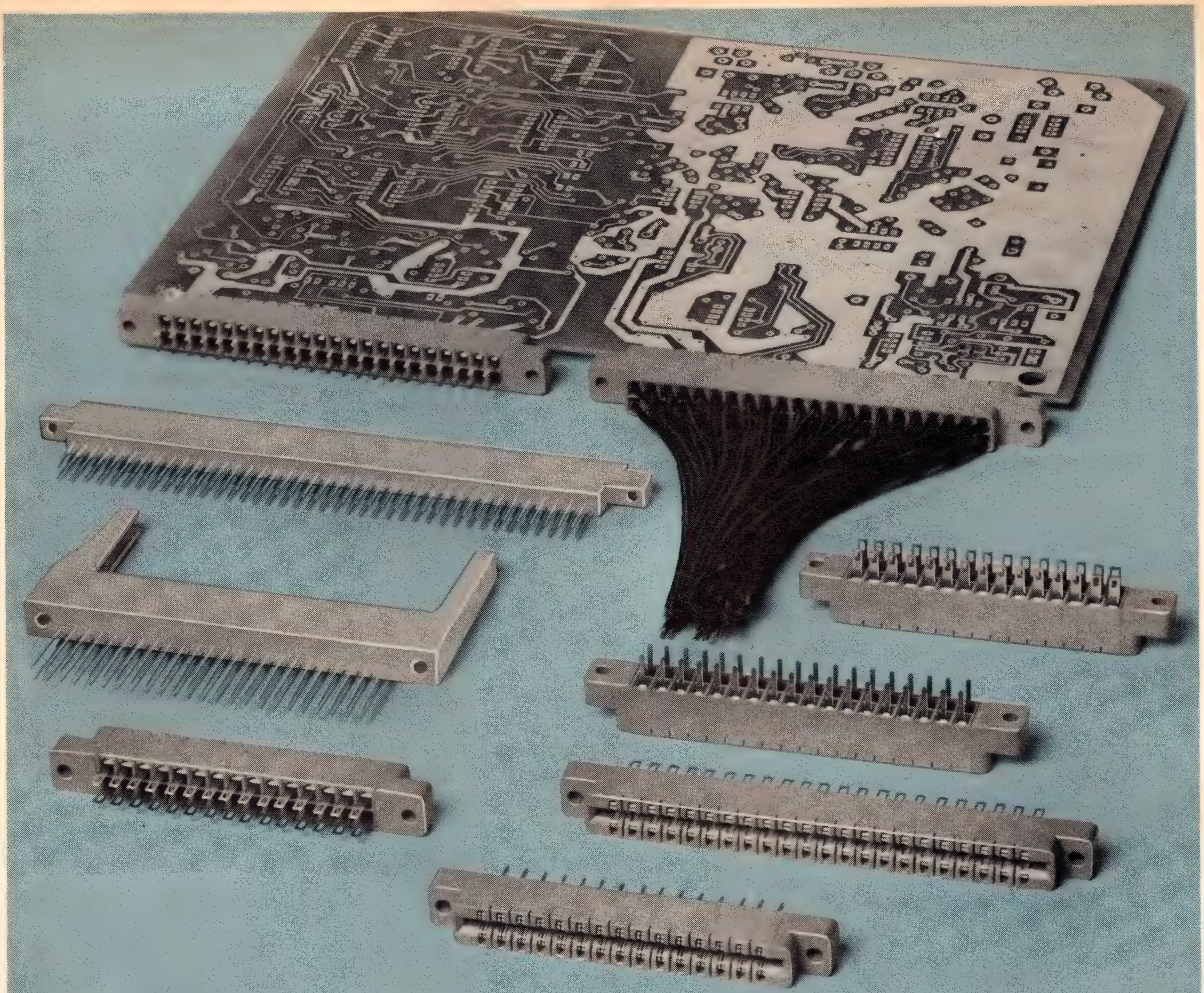

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Simulate analog circuits with digital-filtering circuits

These equations let users breadboard virtually any circuit that can be built in hardware with equivalent software.

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Designing simple digital equivalents of analog filters without resorting to Z transforms is possible with the following method. Users can then replace many analog circuits with a μP, as well as breadboarding them on a programmable calculator, microcomputer or minicomputer to determine signal responses described in the time domain.

Computers are very "discrete"

The key to this technique is to describe the voltage on a capacitor at discrete sample intervals. Capacitor voltage is usually written as:

$$V(t) = V(0) + \int_0^t i(t)\,dt \qquad (1)$$

This is a "continuous time" equation since time can be any value we choose. But a digital computer must use "discrete time" equations because the computer can only calculate the voltage at a finite number of specific times. Thus, **Eq. 1** must be modified slightly and assumptions made about what happens between the samples.

First, divide time into a number of small increments, Δt. Then compute the voltage on the capacitor after one Δt, after two Δt's, and in general, after "k" Δt's. The kth value of the voltage will be equal to the previously computed value—the (k-1) value—plus the integral of the charging current during the time interval between samples divided by the capacitor value. Mathematically, this can be written as:

$$V(k) = V(k-1) + \frac{1}{C}\int_{t=(k-1)\Delta t}^{t=k\Delta t} i(t)dt \qquad (2)$$

Since the voltages and currents in the circuit

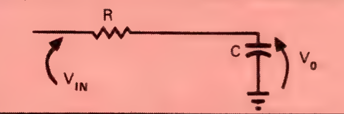
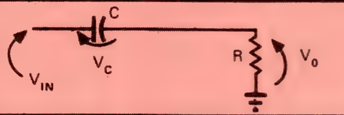
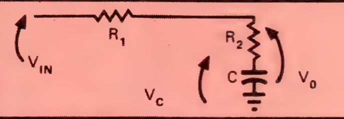
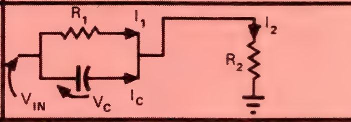
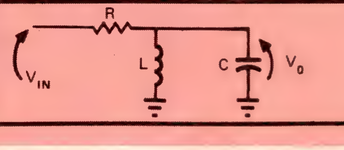
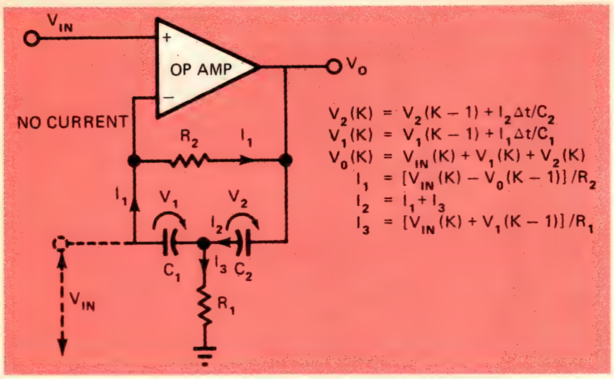
NETWORK	TRANSFER FUNCTION (FREQUENCY DOMAIN)	CIRCUIT MODEL	DISCRETE TIME EQUATION
LOW PASS	$\frac{a}{s+a}$	 $\frac{1}{RC} = a$	$V_0(K) = a\Delta t\, V_{IN}(K) +$ $(1 - a\Delta t)V_0(K-1)$
HIGH PASS	$\frac{s}{s+a}$	 $\frac{1}{RC} = a$	$V_C(K) = a\Delta t\, V_{IN}(K) + (1 - a\Delta t)V_C(K-1)$ $V_0(K) = V_{IN}(K) - V_C(K)$
LAG/LEAD	$\frac{b(s+a)}{a(s+b)}$ $a > b$	 $\frac{1}{R_2C} = a$ $\frac{1}{(R_1+R_2)C} = b$	$V_C(K) = b\Delta t\, V_{IN}(K) + (1 - b\Delta t)V_C(K-1)$ $V_0(K) = b\, V_{IN}(K)/a + (1-b/a)V_C(K)$
LEAD/LAG	$\frac{(s+a)}{(s+b)}$ $b > a$	 R_1 I_1 I_2 R_2 V_{IN} V_C I_C $\frac{1}{R_1C} = a$ $\frac{R_1+R_2}{R_1R_2C} = b$	$V_0(K) = V_{IN}(K) - V_C(K-1)$ $V_C(K) = V_C(K-1) + b\Delta t V_0(K) - a\Delta t V_{IN}(K)$
BAND PASS	$\frac{as}{s^2 + as + b^2}$ $f_0 = \frac{b}{2\pi}$ $Q = \frac{b}{a}$	 $\frac{1}{RC} = a$ $\frac{1}{LC} = b^2$	$I_L(K) = I_L(K-1) + b\Delta t\; V_0(K-1)$ $V_0(K) = a\Delta t\, V_{IN}(K) + (1 - a\Delta t)\, V_0(K-1)$ $- b\Delta t\, I_L(K)$

Fig. 1—Discrete time equations are illustrated here for five common transfer functions. The well-known frequency-domain transfer functions are also shown for each analog circuit.



V_{IN}
OP AMP
+
−
V_0
NO CURRENT
R_2
I_1
I_1
V_1
V_2
I_2
C_1
I_3
C_2
R_1
V_{IN}
$V_2(K) = V_2(K-1) + I_2\Delta t/C_2$
$V_1(K) = V_1(K-1) + I_1\Delta t/C_1$
$V_0(K) = V_{IN}(K) + V_1(K) + V_2(K)$
$I_1 = [V_{IN}(K) - V_0(K-1)]/R_2$
$I_2 = I_1 + I_3$
$I_3 = [V_{IN}(K) + V_1(K-1)]/R_1$

Fig. 2—Some circuits exist that cannot be modelled with the five transfer functions of **Fig. 1.** This bridged-T bandpass filter shows how to derive the equations for such cases.

are only sampled every Δt sec, we cannot know the value of i(t) between time (k-1)Δt and k Δ t, and thus should assume that it is a constant value. If i(t) is assumed to be i(k), then it can come out of the integral. The integral of dt from (k-1)Δt to kΔt is now seen as Δt; and so yields the discrete equation:

$$V(k) = V(k-1) + \frac{i(k)}{C}\Delta t \tag{3}$$

From this equation the discrete time equation can be derived for the five basic networks shown in **Fig. 1.**

Tackling low-pass filters

The first network illustrated is a simple low-pass filter. Its output voltage is the voltage across a capacitor, and thus must be described by **Eq. 3.** Since the sampling rate (Δt) and the capacitor are known values, and V(k-1) is the capacitor voltage previously calculated and stored in memory (or it is the initial condition), all we need do is find i(k) to compute V(k). The current i(k) is given by $[V_{IN}(k) - V(k)]/R$.

Since the voltage will not change instantaneously across a capacitor, $[V_{IN}(k) - V_0(k)]/R$ will approximately equal $[V_{IN}(k) - V_0(k-1)]/R$. From this approximation it follows that:

$$V_0(k) = V_0(k-1) + \frac{V_{IN}(k) - V_0(k-1)}{RC}\Delta t \tag{4a}$$

$$= a\Delta t V_{IN}(k) + (1 - a\Delta t)V_0(k-1) \tag{4b}$$

where a = 1/RC. This general equation can simulate, in the time domain, any network that has the transfer function $a/(s+a)$ in the frequency domain.

In the single-pole, high-pass network shown in **Fig. 1,** the output is equal to the input voltage minus the voltage on the capacitor. The circuit analysis is very similar to that of the low pass just described, and the final result is:

$$V_C(k) = a\Delta t V_{IN}(k) + (1 - a\Delta t)V_C(k-1) \tag{5a}$$

$$V_0(k) = V_{IN}(k) - V_C(k) \tag{5b}$$

Analyzing lag/lead networks

The next basic network is the lag/lead, obviously very similar to the single-pole low pass. In this case, however, output voltage is the voltage on a capacitor plus the current times R_2. The current is approximately $[V_{IN}(k) - V_C(K-1)]/(R_1 + R_2)$; when this is substituted into **Eq. 3,** the resulting value gives the voltage on the capacitor. Adding that to R_2 times the current finally results in:

$$V_C(k) = b\Delta t V_{IN}(k) + (1 - b\Delta t)V_C(k-1) \tag{6a}$$

$$V_0(k) = bV_{IN}(k)/a + (1 - b/a)V_C(k) \tag{6b}$$

where $a = 1/(R_2C)$ and $b = 1/[(R_1 + R_2)C]$.

Behind every lead/lag network...

The lead/lag network strongly resembles a high pass because its output voltage equals the input voltage minus the capacitor voltage. We do not obtain identical results however, because the capacitor charging current is different.

If Δt is small, $V_C(k)$ approximately equals $V_C(k-1)$, and the output equation can be immediately written as:

$$V_0(k) = V_{IN}(k) - V_C(k-1) \tag{7a}$$

Although the output value is known, we must also calculate the voltage on the capacitor to have the value of $V_C(k-1)$. Looking at **Fig. 1** for the definitions of the various currents, we see that $I_C(k) = I_2(k) - I_1(k)$. Since $V_0(k)$ is known we can determine that $I_2(k) = V_0(k)/R_2$ and $I_1(k) = [V_{IN}(k) - V_0(k)]/R_1$. This gives us $I_C(k)$, which can be put into **Eq. 3** to yield:

$$V_C(k) = V_C(k-1) + b\Delta t(k) - a\Delta t V_{IN}(k) \tag{7b}$$

Now $a = 1/(R_1C)$ and $b = (R_1 + R_2)/(R_1R_2C)$.

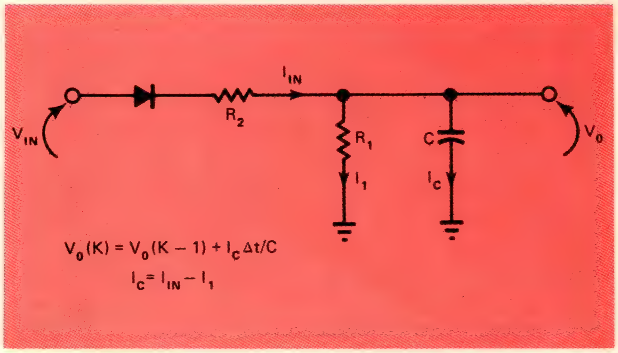


Fig. 3—Nonlinear circuits, such as this peak detector, are handled very much like linear circuits.

Something old, something new

The network for the final transfer function, the bandpass, resembles the low-pass except that the charging current is given by the current in the resistor minus the current in the inductor. Now for the first time, a discrete time equation for the current in an inductor is needed. Fortunately, the continuous time equation for the current in an inductor **(Eq. 8)** is the dual of the continuous time equation for voltage on a capacitor.

$$I(t) = I(0) + \frac{1}{L}\int_0^t V(t)dt \qquad \textbf{(8)}$$

Making the same assumptions as in previous cases results in:

$$I(k) = I(k-1) + \frac{V(k)\Delta t}{L} \qquad \textbf{(9)}$$

Since the final equation will use "a's" and "b's" for generality's sake, we must eliminate terms like R, L and C. Because **Eq. 9** contains a stray L and **Eq. 3** a lone C, knowing that $1/(LC) = b^2$ is not sufficient: We must choose values for L and C. Though in this instance we can choose any value of L and solve for C (and vice versa), the procedure is easier if $L = C = 1/b$. Then, if $a = 1/RC$, we have:

$$I_L(k) = I_L(k-1) + b\Delta t V_0(k-1) \qquad \textbf{(10a)}$$

$$V_0(k) = a\Delta t V_{IN}(k) + (1 - a\Delta t)V_0(k-1) - b\Delta t I_L(k) \qquad \textbf{(10b)}$$

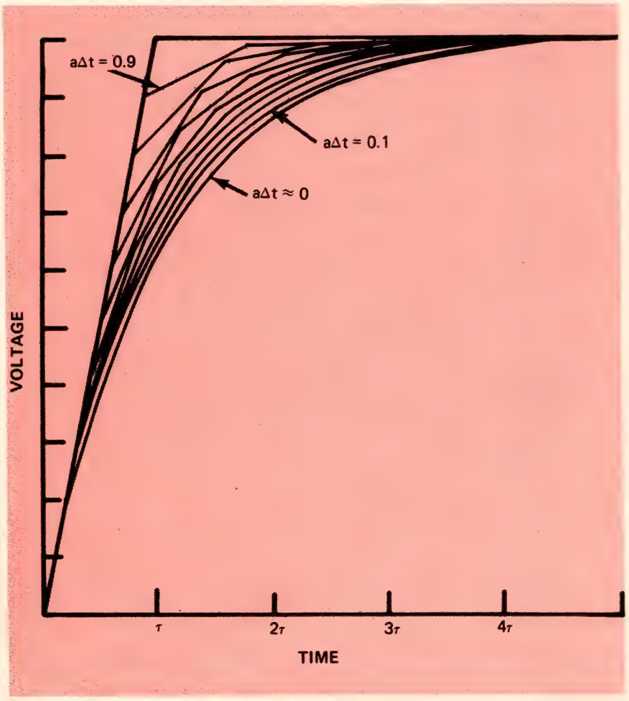


Fig. 4—Simulated step response of a single-pole, low-pass filter is shown for various values of aΔt in 0.1 steps from essentially zero to 1.0.

When the shoe does not fit

Often the desired transfer function can be broken down into factors modelled after the five common transfer functions shown in **Fig. 1.** Unfortunately, some transfer functions do not resemble a product of the five just described. It is then necessary to derive equations for the circuit that produced the transfer function.

The active bridged-T bandpass filter shown in **Fig. 2** provides one such example. Begin by making the usual op-amp assumptions. Voltage on both input pins is the same and no current flows into the input terminals. Also, the output voltage will equal the input voltage plus the voltage on each of the capacitors. To determine the voltage on the capacitors requires calculating the charging currents. Since no current flows into the op amp, current I_1 (which charges C_1) is also the current flowing through R_2. Therefore: $I_1 = [V_{IN}(k)-V_0(k-1)]/R_2$; charging current I_2 equals I_1 plus I_3; and inspection shows $I_3 = [V_{IN}(k)+V_1(k-1)]/R_1$. Combining these equations yields:

$$V_2(k) = V_2(k-1) + \left(\frac{1}{R_2C_2} + \frac{1}{R_1C_2}\right)\Delta t V_{IN}(k) - \frac{\Delta t}{R_2C_2}V_0(k-1) + \frac{\Delta t}{R_1C_1}V_1(k-1) \qquad \textbf{(11a)}$$

$$V_1(k) = V_1(k-1) + \frac{V_{IN}(k) - V_0(k-1)}{R_2C_1}\Delta t \qquad \textbf{(11b)}$$

$$V_0(k) = V_{IN}(k) + V_1(k) + V_2(k) \qquad \textbf{(11c)}$$

Enter nonlinear circuits

Nonlinear circuits are handled in much the same manner as linear circuits. A good illustration is the diode peak-detector circuit shown in **Fig. 3.** Since the output is again a capacitor voltage, we need only find the charging current: I_1, of course, equals $V_0(k-1)/R_1$; and I_{IN} is the voltage across R_2 divided by R_2, if the voltage is positive. Subtracting I_1 from I_{IN} then gives the charging current. The equations that must be implemented on a microprocessor or minicomputer are:

$$\left.\begin{array}{ll} \text{if} & V_{IN}(k) - V_0(k-1) > 0.6 \\ \text{then} & I_{IN}(k) = [V_{IN}(k) - V_0(k-1) - 0.6]/R_2 \\ \text{otherwise} & I_{IN}(k) = 0 \end{array}\right\} \qquad \textbf{(12a)}$$

$$\text{thus} \quad V_0(k) = \left(1 - \frac{\Delta t}{R_1C}\right)V_0(k-1) + \frac{I_{IN}(k)\Delta t}{C} \qquad \textbf{(12b)}$$

If R_2 is very small, **Eq. 12a** could blow up; so, alternately we might use:

$$\left.\begin{array}{ll} \text{if} & V_{IN}(k) - V_0(k-1) > 0.6 \\ \text{then} & V_0(k) = V_{IN}(k) - 0.6 \\ \text{otherwise} & V_0(k) = \left(1 - \frac{\Delta t}{R_1C}\right)V_0(k-1) \end{array}\right\} \qquad \textbf{(12c)}$$

Too big or small Δt spells calamity

Intuitively, we recognize that Δt must be such that the approximations hold to produce accurate results. But smaller Δt's mean more computations per unit of simulated time, resulting in longer running programs. In addition to these constraints, certain selections of Δt would be very poor indeed.

For example, many of the equations in **Fig. 1** contain terms like (1-aΔt) and (1-bΔt). Under normal conditions, Δt is selected to be small enough that $a\Delta t < 1$, so the quantity in the parentheses is always positive, thus giving a stable output. If, on the other hand, Δt is large enough that (1-aΔt) is negative, the capacitor voltage will appear to oscillate. So, in all cases, Δt must be selected so that terms such as (1-aΔt) and (1-bΔt) are always positive.

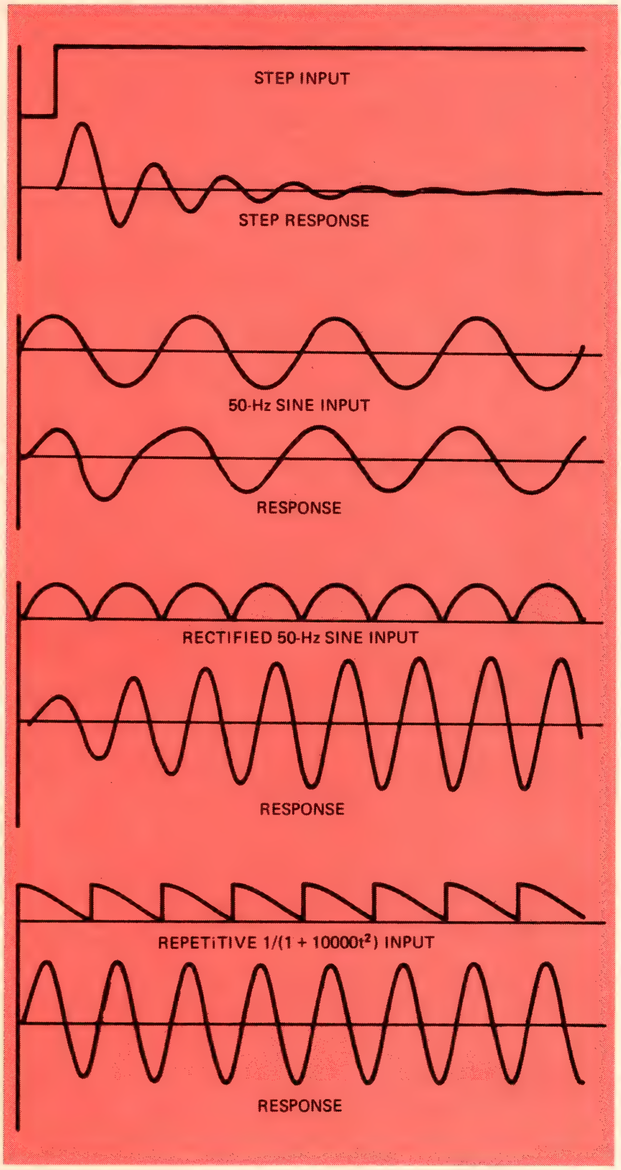


Fig. 5—Simulated performance of the circuit is characterized by the transfer function of **Eq. 13.** An HP 9820 with plotter was used to solve this equation and the entire process from programming to plotting took under half an hour.

Fig. 4a shows the response of a low-pass filter to a unit step input with various values of Δt. Depending upon how accurate the simulation must be, we can select the proper aΔt product. A good rule of thumb in many cases holds that all terms like aΔt should be 0.25 or smaller.

However, a danger exists in selecting Δt too small, especially in the case where the equations will be implemented on a μP with 8- to 16-bit words. If Δt is significantly smaller than 1, the computational device might perform the operation (1−almost zero) = 1. The discrete time equation for a low pass could thus reduce to $V_0(k) = V_0(k-1)$—not a terribly useful equation!

Estimated values improve simulation

In some cases values of Δt may occur on the order of 0.5 or 0.7, leading to insufficiently accurate simulations. A simulation can be improved to some extent with more elaborate equations using estimated values.

The simulation begins to fall apart when aΔt gets large because the assumption that V(k) = V(k-1) no longer holds. We can easily see how this condition affects low-pass simulation: The charging current at the beginning of the time interval Δt was $[V_{IN}(k)-V_0(k-1)]/R$ and at the end of that interval was $[V_{IN}(k)-V_0(k)]/R$; if these two currents are significantly different, we really cannot say that i(t) is a constant value and pull it out of the integral as before.

Even though i(t) is not a constant value, it may still be assumed so; but we should choose some other value than $[V_{IN}(k)-V_0(k-1)]/R$. A better value, then, would be the average current flowing during the time interval, which can be estimated by calculating the capacitor voltage in the usual way and calling this value V(k)′. Since the average capacitor voltage is probably close to $[V(k-1)+V(k)']/2$, this can be used as the capacitor voltage in the previous calculation to yield: $i(k) = \{V_{IN}(k)-[V(k-1) = V(k)']/2\}/R$. The procedure is repeated by going back and using this value of i(k) to recompute the capacitor voltage.

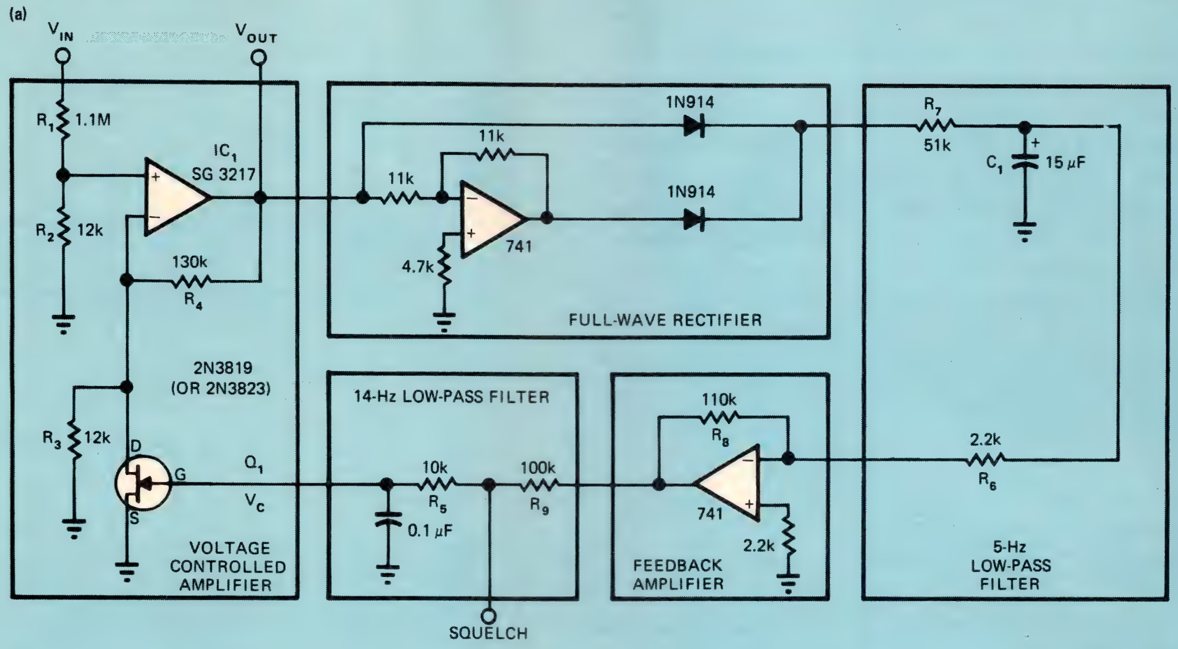
To demonstrate how a particular linear circuit might respond to a variety of input signals, let's look at the following network. Assume that the circuit has a transfer function of:

$$\frac{V_0}{V_{IN}} = \frac{3.925 \times 10^5 s}{s^3 + 439s^2 + 4.3925 \times 10^5 s + 1.256 \times 10^8} \qquad \textbf{(13a)}$$

$$= (10)\left(\frac{314}{s+314}\right)\left(\frac{125s}{s^2 + 125s + 4 \times 10^5}\right) \qquad \textbf{(13b)}$$

Looking at **Eq. 13b,** we recognize that the various factors represent a gain of 10, 50-Hz low-pass filter, 100-Hz bandpass filter and Q of 10.

The next step is to select Δt. The low-pass



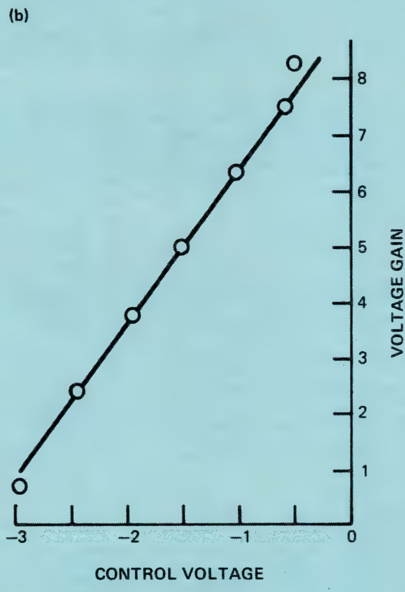


Fig. 6—Schematic diagram of a typical AGC amplifier (a) shows the individual circuit blocks. Voltage gain of the voltage-controlled amplifier **(b)** is almost linearly related to the control voltage: The slope is slightly less than three.

equation will contain a $314\Delta t$ term; the bandpass equation, both a $125\Delta t$ term and a $632.5\Delta t$ term (since the square root of 4×10^5 is 632.5). If we let Δt be 0.1 msec, then $632.5\Delta t$ will be 0.06325, and the $125\Delta t$ term will be 0.0125.

Finally, the following steps must be converted into whatever language the particular computer used understands:

1. Initially all capacitors are discharged, and no current flows in the inductor. Δt is 0.1 msec.
2. Start a loop at time zero and increment it by Δt each time through the loop, stopping at 80 msec.
3. Calculate input voltage using the function.
4. The output of the low-pass section will be $314\Delta t$ times the input voltage, plus the previous low-pass output multiplied by one, minus $314\Delta t$: $V_0 = 314\Delta t V_{in} + (1\text{-}314\Delta t)V_0$.
5. The inductor current will be the previous value of the inductor current, plus $632.5\Delta t$ times the previous value of the bandpass-filter output: $I_L = I_L + 632.5\Delta t\ V_B$.
6. The bandpass-filter output will be $125\Delta t$ times the input voltage, plus the quantity one, minus $125\Delta t$, multiplied by the previous value of the bandpass output with $632.5\Delta t$ times the inductor current subtracted from it: $V_B = 125\Delta t V_0 + 1 - 125\Delta t V_B - 632.5\Delta t I_L$.
7. Finally, plot 10 times the bandpass output ($10V_B$) as a function of time and go back to the beginning of the loop.

Not much computer capability is needed to solve these equations. (I used the HP 9820 programmable calculator with plotter.) **Fig. 5** shows the input and output for each of my test signals.

To prove the value of this analysis technique, try confirming that the output waveforms are correct using any other analysis procedure (Laplace transforms, fourier transforms, building a breadboard circuit, etc.). True, the unit-step response and steady-state response to a 50-Hz sine wave are easy to obtain using common analysis procedure, but the full-wave rectified sine wave will take a bit longer and $V_{IN} = 1/(1 + 10000t^2)$ will be unwieldy. Finally, note that writing the programs, entering them into the calculator, and plotting graphs took less than a half hour!

AGC amplifier simulation

To further illustrate the power of this technique, consider the amplifier shown in **Fig. 6a.**

The full-wave rectifier can be simulated by taking the absolute value of the output and subtracting the diode voltage drop. In cases where the output is less than a diode drop, a negative value is obtained that can be followed with an "if" statement to set the output to zero.

Now, all that remains is to model the voltage-controlled amplifier. From the plot of voltage gain as a function of control voltage **(Fig. 6b)** and the fact that R_3 sets the minimum gain at 0.137, we can derive the following for the gain as a function of control voltage:

$$\left.\begin{array}{l}\text{if } V_C > -3.37\\ \text{then GAIN} = 2.63V_C + 9\\ \text{otherwise, GAIN} = 0.137\end{array}\right\} \qquad \textbf{(14)}$$

Suppose we want to find the response of the AGC circuit to a sudden input of a 1-kHz sine wave. Although the input sine wave could be calculated as in the previous example, the transient response of this AGC circuit is about 150 msec. Thus, selecting a plotter scale such that one cycle is one inch long will result in about 14 feet of transient response before the cycle reaches the steady state. If, on the other hand, we compress the scale too much, not only will individual cycles be illegible, but the graph paper will turn into a soggy ink blot!

At least two solutions exist for this dilemma. To look at individual cycles of the steady-state response (perhaps to analyze for harmonic content), computing the entire waveform but inhibiting the plotter for the first 150 msec is best.

An alternate method—especially useful with regard to the envelope of the output—is to use the input modulation envelope as the input signal. If any filters exist between the input and the rectifier that would affect the modulation, these effects must be taken into account.

For example, to test the response of the circuit to a sudden sine-wave input, input modulation should be a step function. If the input is capacitively coupled by a large capacitor between R_1 and R_2, remove it, since it will tend to block the step function.

Stepping through the program

Let us now go through the program for the transient response of the AGC circuit. For a 14-Hz filter, a 0.5-msec time increment is sufficient; and if we plot the first 200 msec, 400 calculations will result—which should not take too long.

Initial conditions will be a shorted input for a long period of time so that both capacitors are discharged. Since the control voltage is zero, gain will be nine. Now write out the program:

1. Initially both capacitors are discharged and the gain is nine. Δt is 0.5 msec.
2. Start a loop at time zero and increment by Δt each time through the loop, stopping at 200 msec.
3. Calculate the input voltage.
4. The output voltage then becomes the input multiplied by the gain. If output voltage exceeds a supply voltage, the output equals the supply voltage.
5. Take the absolute value of the output voltage and subtract 0.6V. If this is a positive number, it is the rectifier output; otherwise the rectifier output is zero.
6. The 5-Hz low-pass filter output will be 31.4Δt times the rectifier output, plus (1-31.4Δt) times the previous 5-Hz low-pass output: $V_A = 31.4\Delta t\ V_R + (1\text{-}31.4\Delta t)V_A$.
7. The input to the 14-Hz low-pass filter is −2 times the 5-Hz low-pass output. If this value exceeds a supply voltage, the input to this low-pass filter is the supply voltage.
8. The output of the 14-Hz low-pass filter will be 88Δt times the 14-Hz low-pass input voltage, plus (1-88Δt) times the previous 14-Hz low-pass filter output.

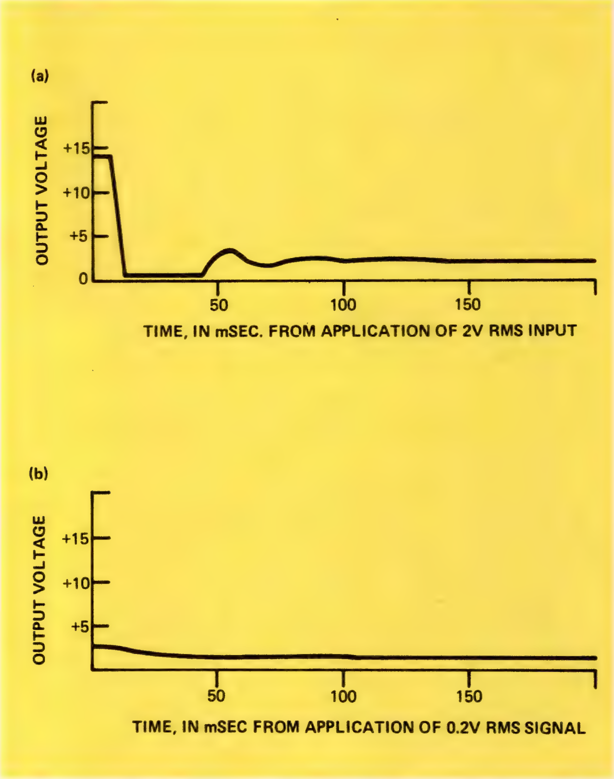


Fig. 7—Transient responses for the sudden application of large **(a)** and small **(b)** signals to circuit in **Fig. 6** differ: The former is underdamped while the latter is not.

9. If the output of the 14-Hz low-pass filter is less than or equal to -3.37V, the gain of the voltage-controlled amplifier is 0.137; otherwise the gain is 2.63 times the 14-Hz low-pass output plus nine.
10. Plot the output as a function of time.
11. Return to the beginning of the loop. (Using an HP 9820 calculator, I came up with plots, shown in **Fig. 7,** that compare quite well with the experimentally determined response of **Ref. 3.)**

Let your calculator do the breadboarding

The equations presented here allow breadboarding in equivalent software of virtually any circuit that can be built in hardware. Of course, software simulation cannot completely replace the hardwired breadboard since it cannot show problems such as noise on the power supply coupling into the input, ground loops, etc.

However, software simulation will provide for faster initial breadboarding. Empty resistor bins, having to unsolder components for every change—these and other annoyances simply don't exist in a software analysis such as this one. Finally, filters or signal-processing circuits that cannot be built in hardware may be implemented with a μP. ☐

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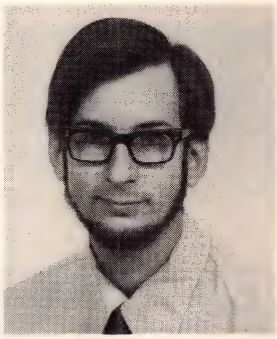
3. Pogge, R. David, "Designer's Guide to: Basic AGC amplifier design," EDN, Jan. 20, 1974.

Author's biography



R. David Pogge is an electronic engineer at Naval Weapons Center, Electro-Optics Div., China Lake, CA. He completed his undergraduate studies with distinction at the Univ. of Nebraska. Dave is not a newcomer to writing, having published previous articles. He also holds an EDN μP Design Contest Award.

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Read Some—No. 309   Read Most—No. 310

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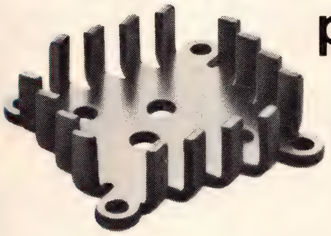

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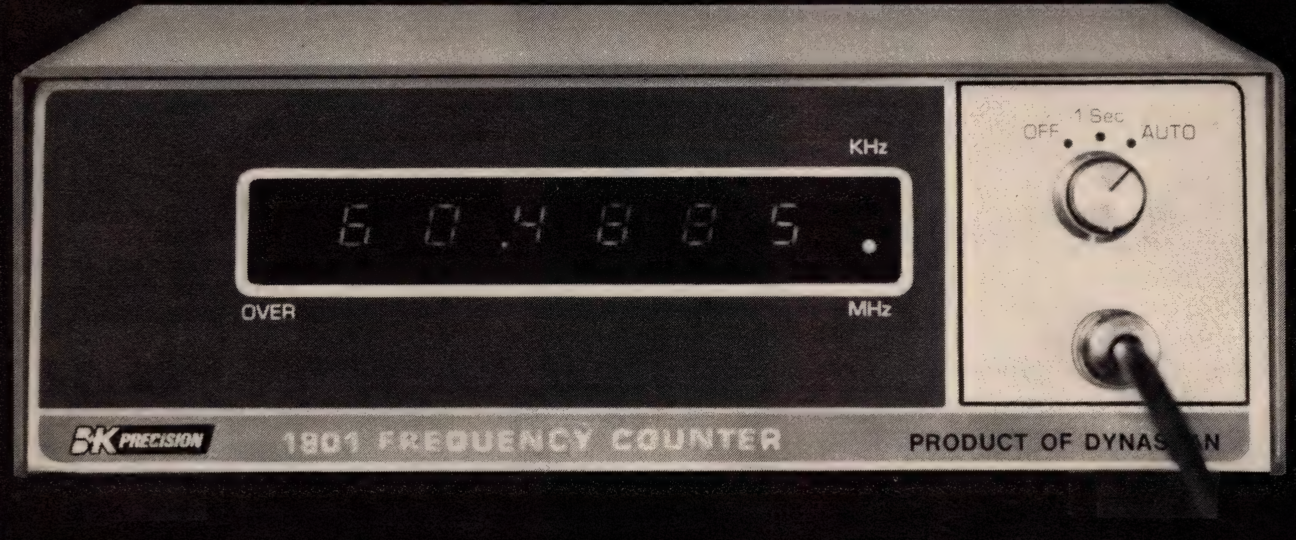

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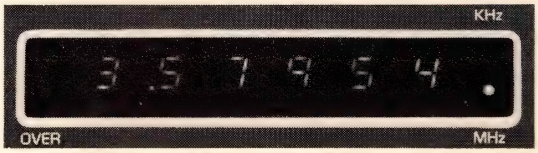
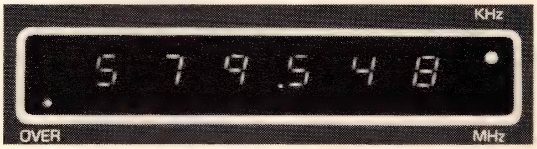


MHz display of 3.579548 MHz input (AUTO mode)



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Microprocessor programming trade-offs—which language is best?

Too often we assume that assembly language and a higher level language are incompatible. Perhaps some rethinking will pay off.

Lynn Carter, Tektronix, Inc.

We must revise the way we think about programming languages. Languages are indeed programmers' tools, and like most tools, no one is perfect for all applications. But many users think an assembly language and a higher level language can never be used together. That belief is not only wrong, it's self-defeating as well. The problem is getting a program into a processor, and a programmer must therefore be able to choose the most appropriate language—or languages!—for his specific application.

When choosing a programming language, then, many costs and advantages must be weighed to avoid the trap of overly simplified yardsticking. For example, the efficiency of the resulting object code in terms of memory used frequently is compared only to direct programming costs. In the real world, profit functions are never simple linear equations. Rather, they are extremely complex ones for which the analytic solutions aren't known. Even if a straightforward equation lies beyond our current knowledge, identification of the variables can be quite beneficial. Accordingly, we'll attempt to identify these variables for microprocessor programming languages.

. . . TO AVOID THE TRAP OF OVERLY SIMPLIFIED YARDSTICKING.

PROGRAMMING–LANGUAGE CONSIDERATIONS*

CONSIDERATION	LANGUAGE CHOICE		
	ASSEMBLY	HIGHER LEVEL	COMBINATION
PROGRAMMING COST	POOR	BEST	GOOD
CONVERSION TO STATE-OF-THE-ART μP	POOR	BEST	GOOD
MEMORY AND EFFICIENCY COSTS AND CONSTRAINTS	BEST	POOR	GOOD
MANPOWER CONSTRAINTS AND SYSTEM AVAILABILITY	POOR	BEST	GOOD
RELIABILITY	POOR	BEST	GOOD

*Yardsticking your needs against this matrix will give you a good start on choosing the best language(s) for your application.

Ed. Note: In our May 20, 1976 issue (pg. 62-67), the article "Is there a high-level language in your microcomputer's future?" by Paul Rosenfeld of Intel Corp. introduced some of the primary factors that must be considered when deciding whether or not to use a higher level language. This article discusses other factors that might be equally relevant, depending on the application.

We will base our discussion on two assumptions: that μP hardware development will continue to make last year's state-of-the-art machine obsolete; and that the user can search the field for the "best" processor for his application. Given these assumptions, we can derive a list of points that the user should carefully consider when selecting a programming tool:

- Direct and indirect programming costs
- Cost of converting to new μP's
- Memory costs
- Memory constraints
- Program-efficiency constraints
- Manpower constraints
- Availability of development systems
- Reliability

Weigh direct and indirect programming costs

Writing a program involves more costs than just the expense of coding, debugging, and maintenance. Consider the costs of change, for example. Educating a programmer or engineer in the use of a new language can be expensive. Then, too, a learning curve always exists as a programmer comes on board. It's unfortunately true that old, tried, known tools are usually the preferred choice, even when a new tool appears better.

Most programs undergo change as well. This is especially true if the product being developed addresses itself to a state-of-the-art market. Sometimes program-modification costs even exceed the initial development cost; thus, the proper choice of a programming tool with regard to flexibility can save substantial money and time.

Examine costs of converting to new μP's

Those instrument manufacturers who don't make their own μP's can choose the "best" one for their product. Unfortunately, if the software development time is long (more than a calendar year), a high probability exists that a better μP will become available before the development is completed.

In such a situation, a designer can avoid needless rewrite time by using programming languages that are machine independent. Thus, he might opt for a high-level language.

Memory costs are language dependent

Some tools are easy to use, others produce precise results, and the ideal one provides both. Unfortunately, higher level languages tend to produce code that requires more memory than a corresponding assembly-language program. Here a trade-off situation occurs where the number of different units to be manufactured must justify the cost of the required extra memory.

Constraints sometimes rule

Some real-time applications require program speed that only the most carefully coded assembly-language programs can attain. In such a case, the speed constraint may force the writing of program sections (or even the total program) in assembly language, regardless of the software development and other costs.

Other constraints, such as those posed by manpower and time, affect language selection. Large projects, for example, require considerable time. Adding more personnel sometimes reduces this time factor, but only to a point. An alternate approach is to make each programmer more efficient through the use of a higher level language.

From another viewpoint, one should keep in mind that reaching the marketplace first frequently outweighs extra cost due to inefficiencies. The user should then ask himself, for each project: "How much money is it worth to have a product on the market six months before the competition?"

"HOW MUCH MONEY IS IT WORTH TO HAVE A PRODUCT ON THE MARKET SIX MONTHS BEFORE THE COMPETITION?"

Time constrains users in other ways, too—some of which can be overcome by a wise choice of language. One instance concerns the unavailability of hardware/software development tools. When these are not available at the appropriate time, the choice of a machine-independent language will permit work to start long before test systems are constructed.

Don't forget reliability!

Arguments for cost savings and reduced time don't mean much when the result is an unreliable system. It is therefore best to choose programming languages designed to help solve the kinds of problems a programmer faces during his project. If the programmer must rearrange the solution to fit the language, the probability of error goes up and reliability drops.

While an answer arrived at too late is no answer, a wrong answer on time serves no purpose either. Users should ask themselves, then: "What is the cost of modifying firmware in systems already in the field, both in real dollars and in loss of customer confidence?"

What this industry really needs is...

If memory and efficiency costs and constraints are not significant, a higher level language is the obvious choice. Unfortunately, these constraints do tend to be important; thus, using only a higher level language can be unjustifiably expensive.

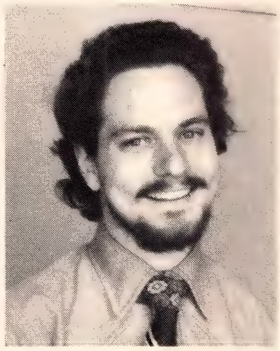
The second-best solution is to identify the most inefficient segments in the code and recode them in assembly language. This approach provides a good, flexible answer for most situations, especially where the significance of the parameters changes.

Though most programmers would prefer to use a higher level language if it produced a sufficiently efficient object code, they sadly continue to code away in primitive assembly languages, waiting for someone to develop a better higher level language compiler. However, the real solution to this problem is a better μP.

. . . THEY SADLY CONTINUE TO CODE AWAY IN PRIMITIVE ASSEMBLY LANGUAGES . . .

By designing a μP's instruction repertoire with a higher level language compiler in mind, manufacturers could make its object code as good as the best hand-coded assembly language. Few manufacturers, however, really address themselves to the fact that only a programmed μP provides the solution to a problem. Without the program, the μP is useless. Therefore, a well-designed μP that permitted the program to be more efficient and less expensive would be a very popular item with designers—and thus a highly successful product for its developer. □

Author's biography



Lynn Carter, a system analyst at Tektronix in Beaverton, OR, presently serves as project leader for the development of TESLA, a higher level language for microprocessors. He holds both BS and MS degrees from Portland State Univ., and is currently a PhD candidate in computer science at the Univ. of Colorado. Lynn enjoys building balsa model planes, bicycling, swimming and playing simulation war games.

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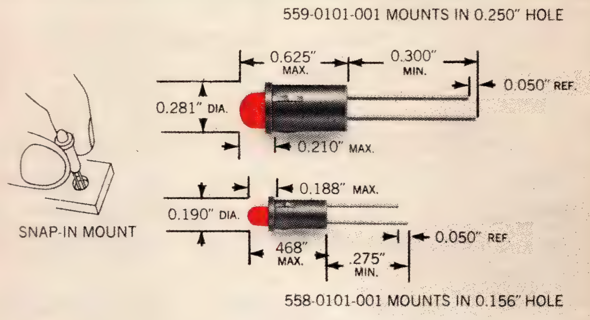

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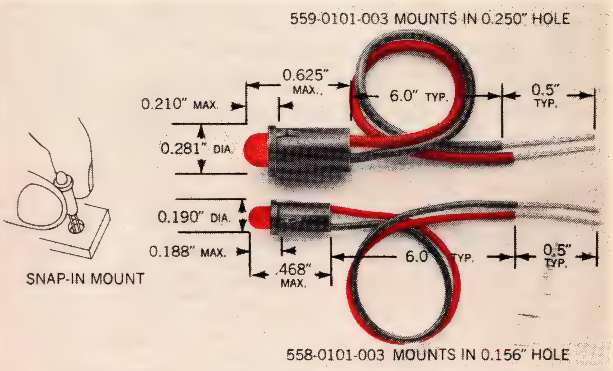

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DESIGN AWARDS

PLL lock indicator uses a single IC

John C. Hanisko
Consultant, Detroit, MI

It is advantageous—sometimes even mandatory—to know exactly when a phase-locked loop has lost lock. The circuit shown in **Fig. 1** provides this information, as well as indicating acquisition of lock.

The operation of this circuit derives from the concept that the loop is locked as long as the static-phase error is less than 90° (quadrature lock). Appropriately off-setting the zero-crossover detector achieves lock-limits for static-phase errors other than 90°. **Fig. 2** shows a timing diagram for the system in a locked condition.

As long as the positive-going edge of V_2 occurs at the time V_4 is negative ($|\phi| < 90°$), the output of the retriggerable one-shot will be LOW. But if V_2 occurs at the time V_4 is positive ($|\phi| > 90°$), the output of the retriggerable one-shot will go HIGH.

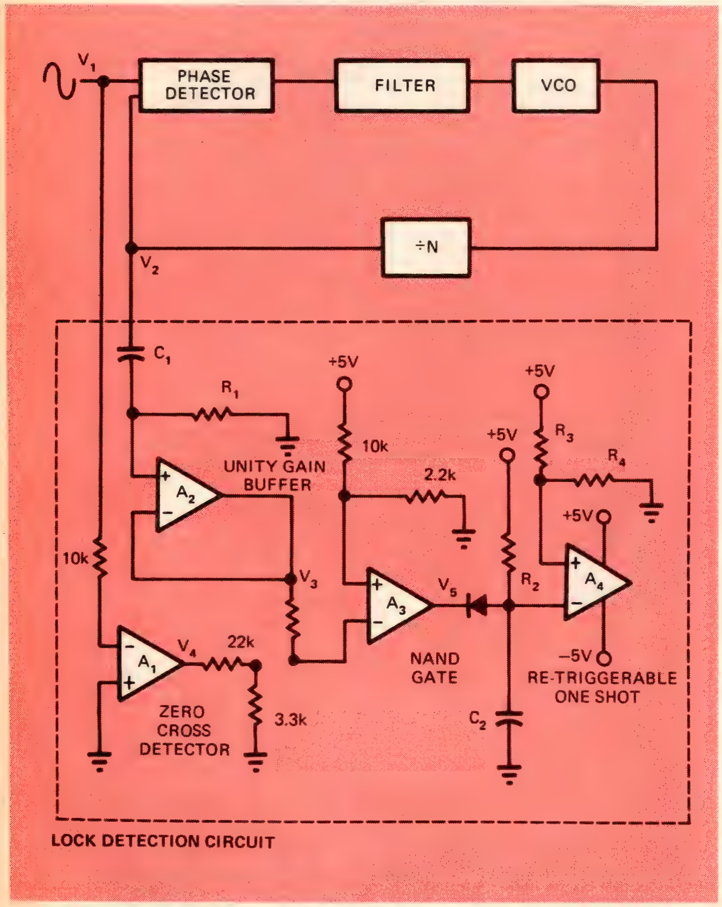

Fig. 1—Loss of lock in a PLL is detected by this lock indicator.

R_1 and C_1 determine the characteristics of the V_3 pulse. R_2, R_3, R_4 and C_2 determine the time duration, t_d, of the one-shot. In general, this time duration should be large relative to the period of the free-running VCO multiplied by N. The output of the one-shot will remain HIGH for t_d seconds after the last out-of-lock pulse (V_5) occurs.

When the system is turned on, the output of the one-shot goes HIGH and remains HIGH until lock is obtained plus t_d seconds, at which time it goes LOW. If during operation lock is lost, the output of the one-shot again immediately goes HIGH and remains HIGH until lock is reacquired plus t_d seconds, at which time it goes LOW once more.

This latter fact proves especially useful in systems where certain processes must be interrupted immediately upon loss of lock, and may proceed again only after definite reacquisition of lock.

Aside from the passive components and the diode, the whole system can be built from one quad op amp package such as the RC4136, thus revealing the simplicity of this detector. □

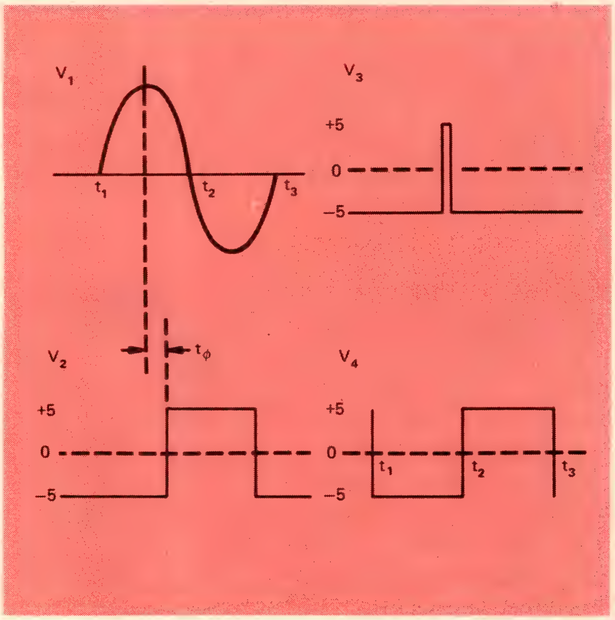

Fig. 2—Waveforms for the lock detector include the PLL input (V_1), divider output (V_2), buffer output (V_3), and zero-crossover detector output (V_4).

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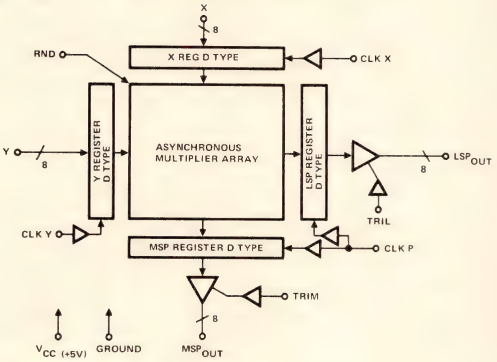

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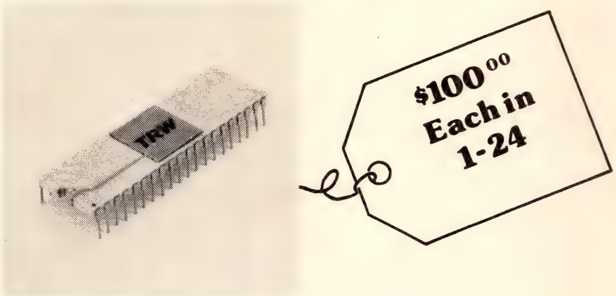

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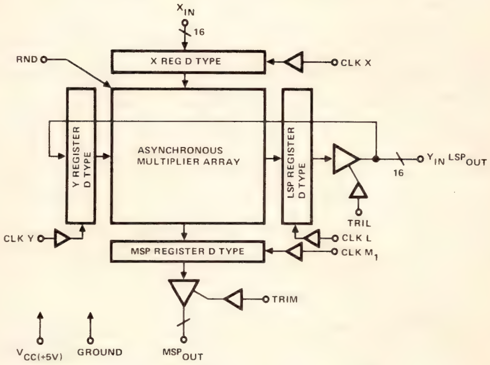

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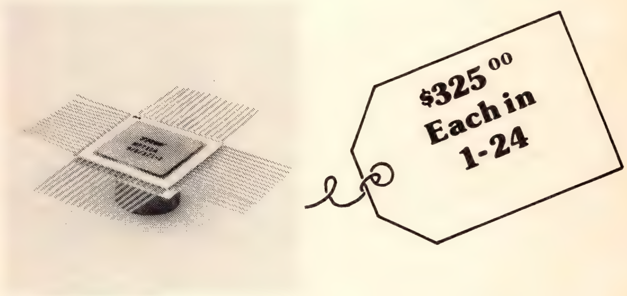

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Line driver is compatible with OCI line receiver

Ken Erickson
Interstate Electronics Corp., Anaheim, CA

The line driver shown provides a balanced differential drive to an optically coupled line receiver. The driver's output impedance was designed to match the characteristic impedance of a 75Ω transmission line, thus minimizing signal reflection at the line receiver. Because of impedance matching with the driver (which absorbs any reflections from the termination), the value of resistor R is calculated to yield only the desired LED current—not to match the transmission line. This value along with the driver-output impedance (about 75Ω) controls the level of the OCI LED current.

Since the open circuit driver-output voltage (5V peak) is much larger than the forward voltage of a LED (typically 1.7V), good control of the LED current is achieved. Diode D_1 is included to provide a current path when the LED is reverse-biased.

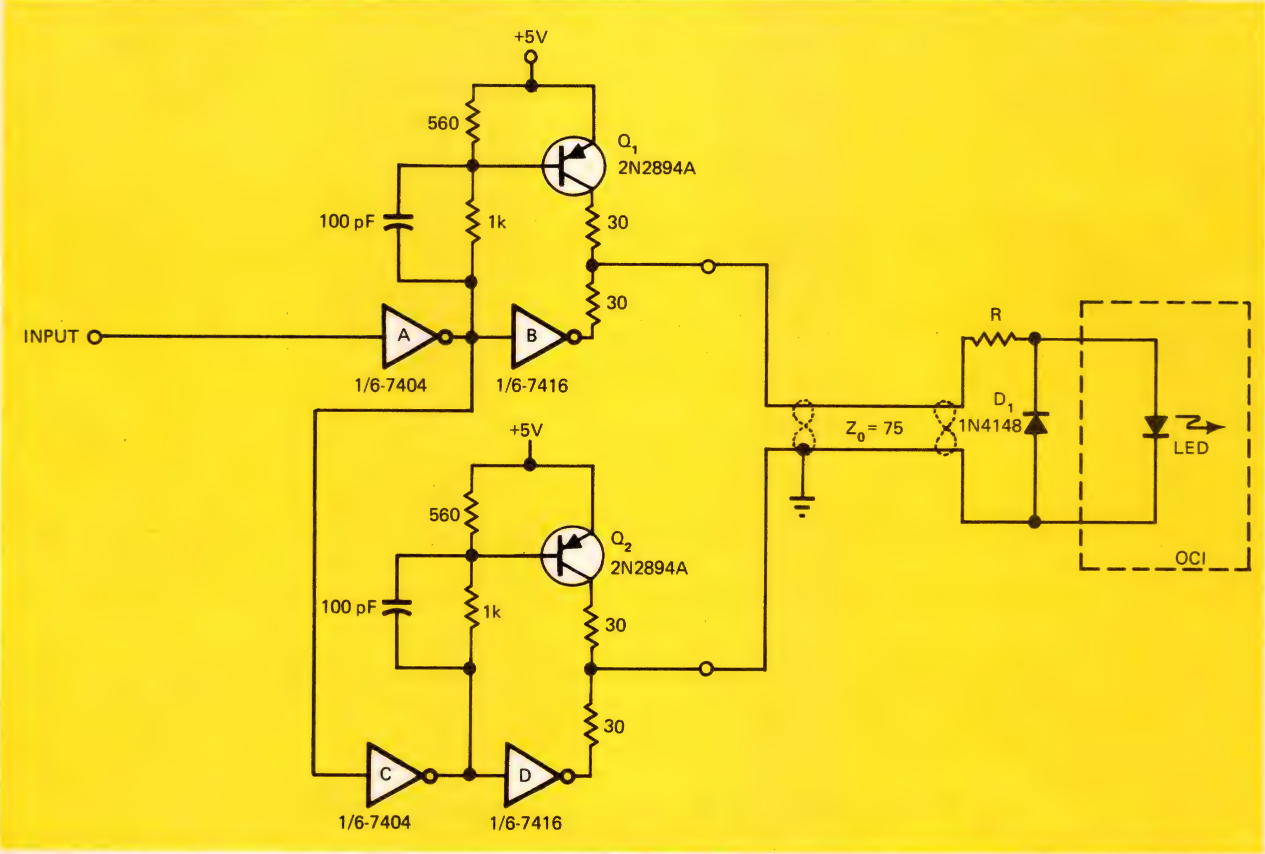
A logic ONE level input to the driver input is inverted to a logic ZERO level by inverter A, thus turning on transistor Q_1 and turning off the open-collector output of gate B. The logic ZERO output of inverter A is then inverted to a logic ONE level by inverter C to inhibit the turn-on of transistor Q_2 and to cause the output of open-collector inverter D to turn ON and go LOW. With the assumed logic ONE input level, current is sourced into the transmission line and LED by transistor Q_1, then sunk by the inverter D output.

Likewise, a logic ZERO level input at the driver input results in the driver-output current being sourced by transistor Q_2 and sunk by inverter B. This causes diode D_1 to conduct, thus turning off the OCI receiver LED.

One-half of the driver circuit shown may be used as a single-ended line driver. However, to maintain impedance matching with a 75Ω cable, change the 30Ω output resistors to about 62Ω.

Propagation delay of the driver is typically less than 50 nsec. □

To Vote For This Circuit
Circle 322



Because the driver is matched to the line, it absorbs any reflections from the termination, which is not matched to the line.

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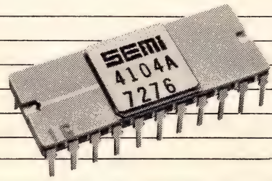

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Divide-by-N uses shift register

Jim N. Hobbs, Jr.
IBM, Research Triangle Park, NC

Useful for those hard-to-get, bulky frequency dividers—and particularly for tracking odd-bit serializer/deserializers—this circuit is easily constructed from TTL logic. As shown in the accompanying figure, a 7496 is used as the 5-bit shift register, a 7486 as an exclusive-OR, and a 7404 as an inverter. The output has a 50% duty cycle.

Assuming a start from reset (all shift-register outputs LOW), the serial input of the shift register has a positive input. The gate leg of the input exclusive-OR is also LOW, so the input frequency is not inverted through that circuit. At the first positive shift on the shift-register clock input, a positive level will be shifted to the A output. On each succeeding shift (logical ZERO to ONE), each successive output (B through E) will go positive.

When the E output goes positive, the serial input of the shift register will be negative, and the gate leg of the exclusive-OR will cause the input frequency to be inverted through that circuit. The clock will then immediately go negative and one-half clock cycle later will shift positive. The clock output of the shift register is now 180° out-of-phase with the input frequency.

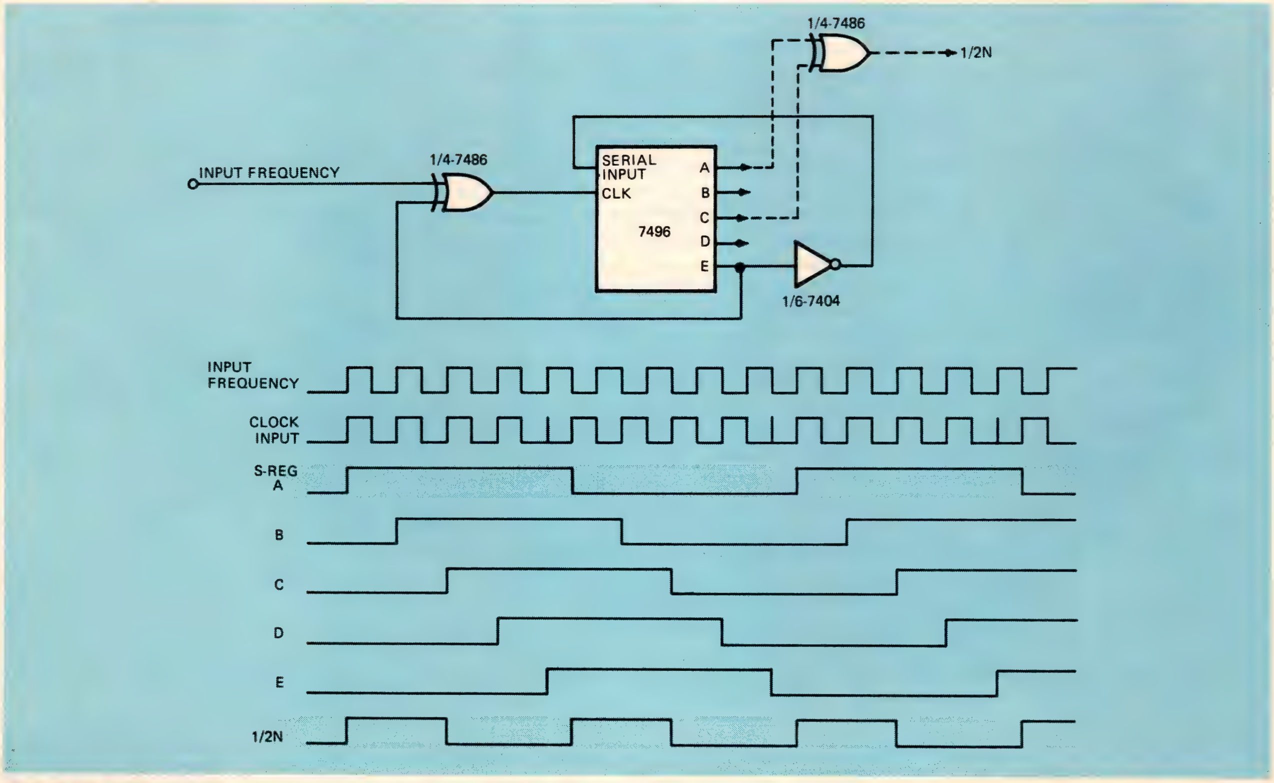
At the next clock-input (positive shift) the LOW level (logical ZERO) at the serial input will transfer to the A output. Each succeeding positive clock shift will then transfer a LOW level to each successive shift-register output, until the E output goes negative, at which time we are back at the starting point: all cycles will be repeated.

The wiring diagram and timing chart show the circuit to be a divide-by-9. However, if the inverter input and gate leg of the exclusive-OR were wired to a different output, the frequency would be some value between one and seven. Depending on the inverter's input connection, the circuit divides-by-1 if the connection is A; divides-by-3, if B; by 5, if C; by 7, if D; and by 9, if E.

If an 8-bit shift register is used, the circuit may divide by as much as 15; and cascading shift registers will allow any odd number.

By adding an exclusive-OR across any of the two outputs, the effective output of that circuit is one-half the basic circuit divisor, or in this case, 4-1/2. The duty cycle is determined by the shift register outputs used. □

To Vote For This Circuit
Circle 323



This 5-bit shift register and associated circuitry divides by 9. In the divide-by-7 version, there is one change: the 7404 input and exclusive-OR input (shown here as connected to output E) are reconnected to D, and E is left open.

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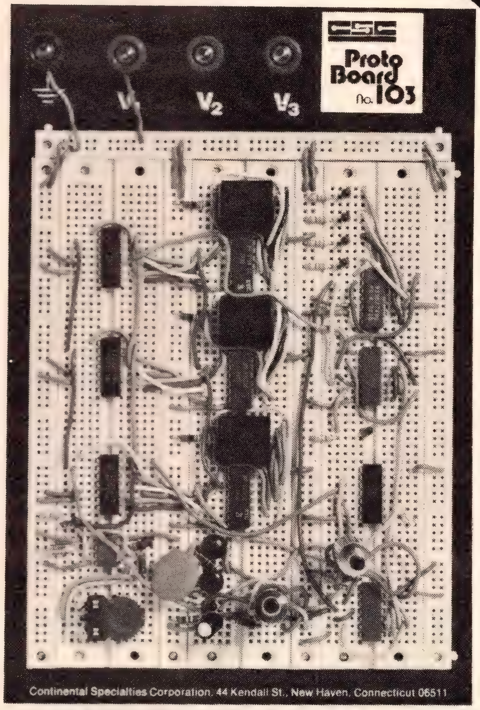
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Build a function generator with a 555 timer

Walter G. Jung
Consultant, Forest Hill, MD

An inexpensive but high-performance function generator can be built from a 555 timer (used as a bilevel threshold detector), bidirectional current source, buffer amp, and a few components.

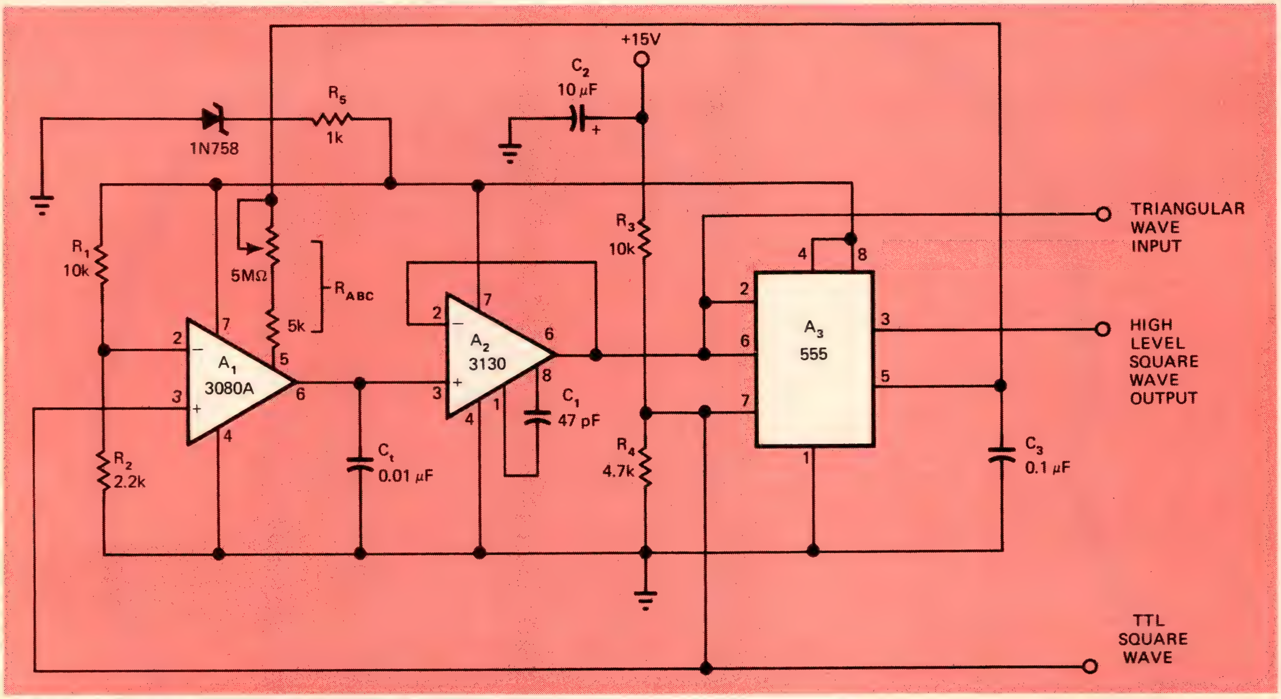
The circuit is based on the linear charge and discharge of a capacitor by a constant current source. In this case, A_1, an operational transconductance amplifier, supplies the constant current. The current output of this device is programmed by variable resistor R_{ABC}, and its polarity is selectable (for ramp up or ramp down) by the relative state of the differential inputs.

A_1 charges the timing capacitor C_t between the 555's two threshold points of +5V and +10V. The resulting linear triangular-wave output is buffered by A_2, a single-supply FET-input op amp. As the triangular wave oscillates between the two thresholds, the 555 is toggled between its HIGH and LOW output states, creating a high-level (≈13V) output at pin 3, and a 5V TTL output at pin 7. The latter output also controls the state of A_1.

The design equation for output frequency is merely $f \approx 1/(R_{ABC}C_t)$, where R_{ABC} is the entire resistance between R_5 and A_1's pin 5 (not a completely precise relation, due to the V_{BE} of the 3080A's input current mirror).

The circuit also adapts well to further modification. For instance, A_2 can be eliminated altogether if a buffered triangular-wave output is not desired and the lowest timing current used is much greater than the 555's threshold current (as in the case shown). On the other hand, timing currents can extend downward to below 1 nA due to the use of A_2 with its FET inputs. This extends the range of operation into the 1000-sec region, while still using reasonable timing components. □

To Vote For This Circuit
Circle No. 324

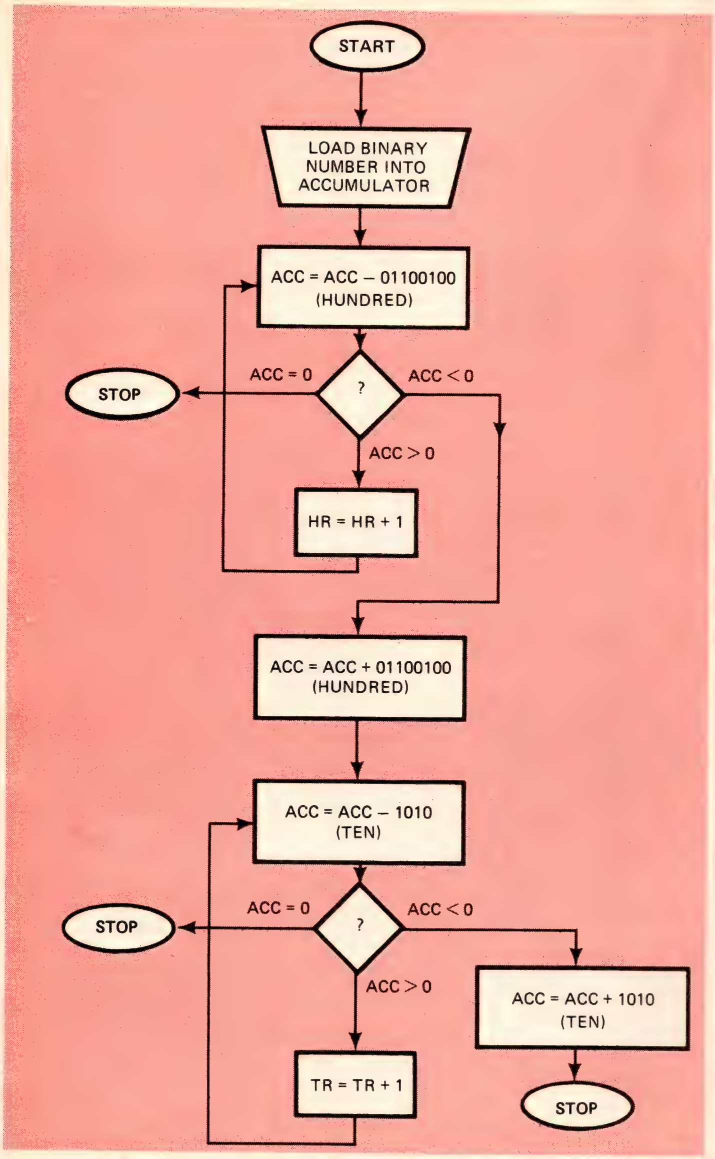


Built with a single-supply 555 timer, this function generator sweeps the audio range (30 Hz-20 kHz) with a single pot rotation.

Binary to BCD conversion with µP's

Dana F. Geiger
Kulite, Ridgefield, NJ

Many microprocessors use the binary number system for arithmetic operations such as addition, subtraction, and so on. Naturally enough, the results of these operations are binary as well, and as such inconvenient to display. It thus proves desirable to convert these binary numbers into BCD, which can then be readily displayed using standard 7-segment decoders and LED's, or any other standard display system.



A flow chart is shown for a μP program that converts an 8-bit binary number to BCD. Upon completion of the program, the hundreds register HR will contain the hundreds digit in BCD; the tens register TR, the tens digit in BCD; and the accumulator ACC, the units digit.

Microprocessors can be programmed to carry out this conversion. Since the principle involved is straightforward, the user can translate the idea into software for his particular machine.

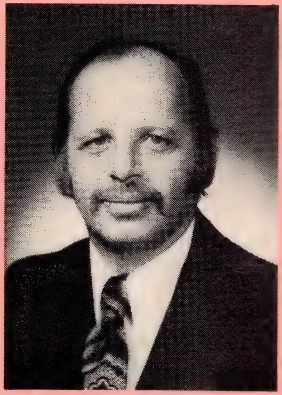
Assume we have an 8-bit binary number to be converted to BCD. The maximum decimal number that will occur for 8 bits is 255 (corresponding to binary 11111111). We then define three registers: the hundreds register HR, the tens register TR, and the units register (used as the accumulator). Naturally, a 10-bit number will require a thousands register, THR.

To begin the conversion, we subtract the binary number 100 (01100100) from the given binary number and determine if the result is positive or negative. If positive, the original number must have been greater than 100 ($N-100 > 0$, $N > 100$). We then increment HR by one, and subtract 100 from the previous result. If at any time the result comes out negative, we branch and immediately add back 100 so that our remaining value is again positive, but now known to be less than 100. When an integral number of 100's has been subtracted, the number of hundreds in the original number is stored in the HR register.

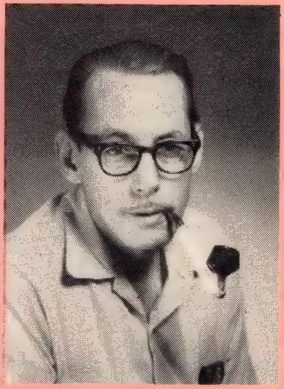
The binary number 10 (1010) is then subtracted from the previous result. Whenever the result is positive, the tens register TR is incremented. As soon as the result of repeated subtractions of 10 becomes negative, the last value before turning negative is recovered by adding back 10. This remainder is the units digit of the final desired result. The HR register now contains the number of hundreds; the TR register, the number of tens; and the accumulator, the number of units. □

To Vote For This Circuit
Circle No. 325

Readers have voted:



Al Pshaenich winner of the February 20, 1976 U.S. Savings Bond Award. His winning circuit is "Gas/smoke detector uses a semiconductor sensor." Mr. Pshaenich is with Motorola, Inc., Phoenix, AZ.



Vernon C. Gregory winner of the May 5, 1976 U.S. Savings Bond Award. His winning circuit is "CMOS touch switches—convenient, less $ and sexy." Mr. Gregory is with Motorola Inc., Phoenix, AZ.

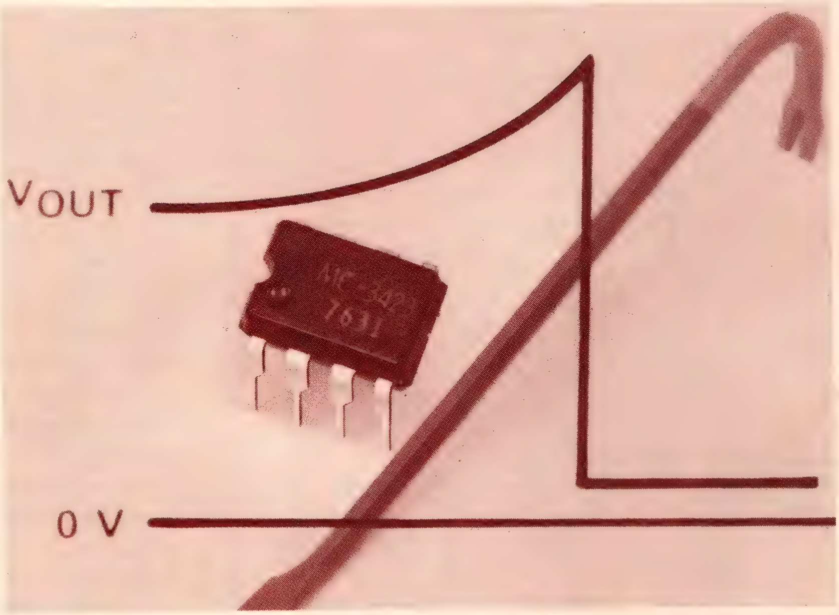
Overvoltage-protection IC will always "let you down"

PROGRESS IN SEMICONDUCTORS

Much of the time and effort that goes into designing circuits to protect complex electronic systems is no longer necessary. Motorola has packaged most of the components of an overvoltage protection (OVP) circuit in a single, 8-pin mini-DIP, the MC3423. In fact, all you need add are a few resistors, one capacitor and an SCR.

The MC3423 can handle a 45V dc differential power-supply voltage; has a 3V, 300-mA output capability; dissipates 625 mW and operates at a 400-mA/µsec output-current risetime rate. Two external resistors set the input trip level, while a single external limiting resistor varies output current.

A quick count of pins—V_{CC}, V_{EE}, sense-voltage input and output—shows that an 8-pin DIP would have four unused pins. Not to let these go to waste, Motorola has added some extra features.



Don't be fooled by its small size. The versatile MC3423 lets users tailor overvoltage protection to their system's needs.

Two inputs for the price of one

For example, a second sense-voltage input can be set independently of the first. Both connect to separate but cascaded internal amplifiers and thus have slightly different propagation delays. Tieing them together gives the shortest possible delay.

False tripping by noise and transients that would not harm the load can be prevented by connecting a capacitor between V_{EE} and sense-input two. When V_{CC} rises above the trip point set by input one, an internal current source (another unused pin) begins charging the capacitor.

If the overvoltage condition remains long enough for the capacitor voltage to reach the trip point, the output activates. But if it disappears before activation, the capacitor discharges at 10× the charging rate, quickly resetting the timing feature. The value of C determines the minimum delay, which can range from < 1 µsec to several seconds.

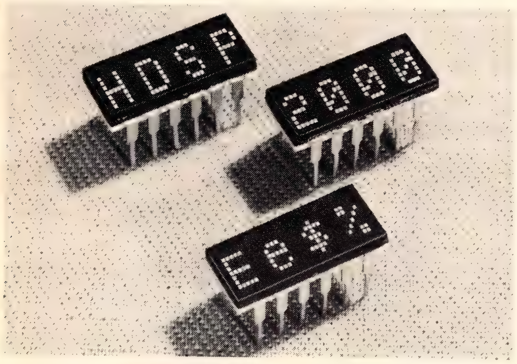
Know when overvoltage exists

Two pins remain. One is an activation-indicator output—an open-collector transistor that saturates when OVP is activated and remains so until the SCR crowbar pulls the supply voltage, V_{CC}, below 4.5V. It can readily activate a panel light or even shut down the power supply to reduce heat-sinking requirements.

The last pin, a remote-activation input, is CMOS/TTL compatible and can be activated whether or not an overvoltage condition exists. It is ideal for an orderly, sequenced shutdown of power supplies during system faults. The MC3423 sells for approximately $1.50 (100).

Motorola Semiconductor Products, Inc., Box 20912, Phoenix, AZ 85036. Phone (602) 962-2122. **Circle No. 297**

Matrix LED display packs more electronics to significantly reduce system parts count



Compared with the external circuitry required for earlier and more expensive alphanumeric LED displays, HDSP-2000 units reduce the parts count for a typical 32-character system by a factor of 36:1.

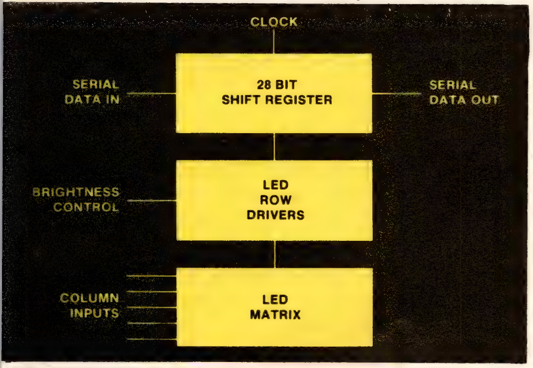
PROGRESS IN SEMICONDUCTORS

Model HDSP-2000, a 4-character, 5×7 matrix display in a 12-pin DIP, incorporates an integral red-glass contrast filter and can display the full ASCII code. Each character measures 0.146×0.083 in., while center-to-center spacings are 0.175 in. Multiple clusters can be end-stacked to form character strings of any desired length.

The new display provides on-board storage of decoded-row data plus constant-current sinking row drivers for each of the 28 rows. Consequently, the user can address each package through just 11 active interconnections. By comparison, competing units require up to 176 connections and 36 components.

Outside, looking in

Internal circuitry consists of four LED matrices and two 14-bit serial-in/parallel-out shift registers. Connections are such that any LED in the 5×7 matrices can be addressed by shifting data to the proper shift-register location and applying voltage to the appropriate column.



You need only 12 pins to address each HDSP-2000 4-character set. On-board electronics includes shift registers and externally programmable constant-current drivers.

All corresponding columns in each digit (all column 1's, 2's, etc.) tie to a single pin. In turn all column 1 pins, etc., in a multichip display, can be tied together. Thus, only five column switch transistors are needed for any size display (assuming they can handle the current), making display multiplexing extremely easy.

Because a viewer may find a display objectionable if too great a difference exists between adjacent characters in a string, HDSP-2000 displays are classified into 8 overlapping intensity categories. All characters of all packages within a given category fall within a 2:1 intensity ratio.

A hot product

The HDSP-2000's significant amount of logic and display capability causes it to dissipate a relatively high 1.7W/package, 165 mW/character. Therefore, users should give careful consideration to the thermal design of the display mounting, especially for long display strings.

The displays sell for $47 per 4-digit package in quantities of 125. Small quantities are available from stock.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501.

Circle No. 298

Amilon's cassette transports are compatible to more standards:

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***E.C.M.A.**
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***Recognized under Component Program of Underwriters Laboratories.**
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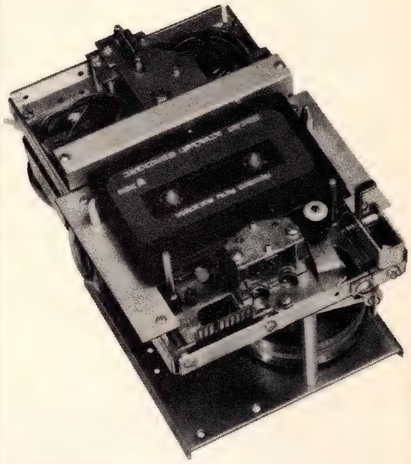

HERE'S PROOF:

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- Read/write speed: 1.875 to 12 ips

Get all these advantages in one cassette transport with versatile applications for about $100 in OEM quantities. True modular construction allows the addition or deletion of many options, tailoring the transport exactly for each application without the cost of unneeded features.

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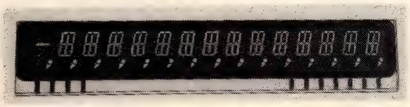
For more information, Circle No. 64

COMPONENTS/PACKAGING

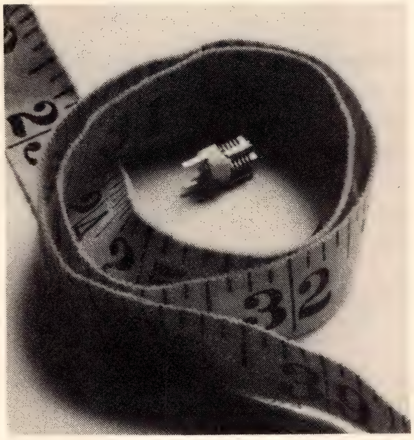


DISPLAY. A gas-discharge unit, the W14-0001 is a 9-segment, 14-digit display that features a multiplexed design to minimize external contacts. The 0.4-in. high characters are easily read at distances to 25 ft—valuable in POS applications. As with all Plasma-Lux displays, this one has a "halo-effect" backlight which results in a more continuous line for greater visibility, clarity and contrast. $19.15. **Cherry Electrical Products Corp.,** 3600 Sunset Ave., Waukegan, IL 60085. Phone (312) 689-7702. **Circle No. 166**

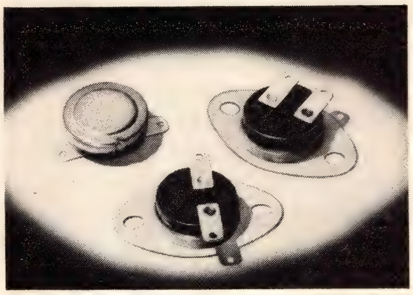
DPM'S. High accuracy, stability and noise immunity are combined with low cost in this pair of 3-1/2-digit units. Model 2860 operates from 120/220V ac line; Model 2861 is a 5V dc version. Both feature a bright 7-segment 0.43-in. red LED readout with automatic polarity, out-of-range indication and fixed decimal. Accuracy is ±0.1% of reading +1 digit. Stock ranges include 200 mV to 200V and 20 μA to 200 mA. $69 (2861); $79 (2860). **Simpson Electric Co.,** 853 Dundee Ave., Elgin, IL 60120. Phone (312) 697-2260. **Circle No. 167**

LCD'S. The 3-1/2-digit displays in the 3603 Series can be battery-powered for >1 yr in portable clock applications. Available with either light or dark digits on contrasting backgrounds, these units read to 11:59 and feature 0.5-in. high characters easily read from 15-20 ft. Both reflective and transmissive light displays are available. While the leads may be soldered directly, the displays are designed for single-edge mounting. $12 (1000). **UCE Inc.,** 20 N. Main St., Norwalk, Ct 06854. Phone (203) 838-7509. **Circle No. 168**

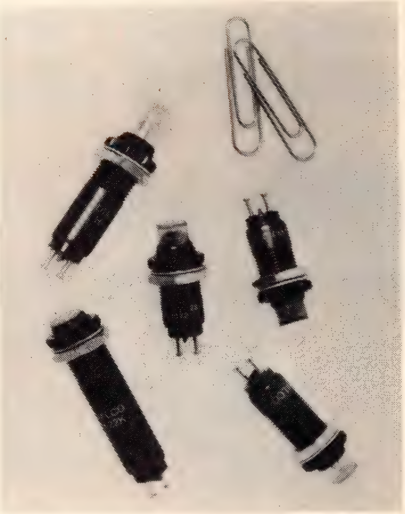
CAPACITORS. Units in the 9371 Series of ceramic trimmer capacitors are compact (50% smaller than others of this type), economical and rugged. They are available in 4 capacitance ranges: 1.5 to 4, 3 to 10, 3.5 to 18 and 5 to 25 pF with Q's >300 at 10 MHz. These units have an overall dia. of 0.225 in., above-the-board height of 0.215 in., and meet or exceed MIL-C-81. 75¢ (1000). **Johanson Mfg. Corp.,** 400 Rockaway Valley Rd., Boonton, NJ 07005. Phone (201) 334-2676. **Circle No. 169**



CAPACITORS. The Micro-T series air-dielectric types have their rotor and stator precision-machined from brass extrusions. Designed to mount interchangeably with ceramic trimmers of similar dia. (0.22 in.), they are available in max. values of 5, 10, and 15 pF in either vertically or horizontally tuned pc-mounting versions. Units have a Q of > 1000 at 100 MHz and a capacitance TC of +30 ±15 ppm/°C. $1 (100). **E. F. Johnson Co.,** 299 10th Ave. S.W., Waseca, MN 56093. Phone (507) 835-5222. **Circle No. 170**



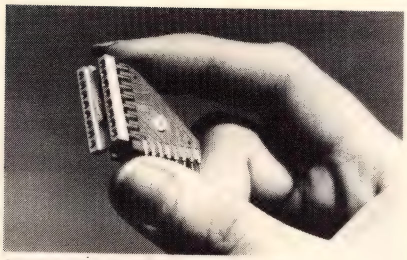
THERMOSTATS. Series 5003 snap-action disc thermostats boast a thin low-silhouette wafer construction, Their spst single-break contacts are rated for 5A resistive at 120V ac or 3A resistive at 240V ac, and have a lifetime of 10^5 cycles. Units can be factory-set to any operating temp. in a −20 to +350°F range, and come in a variety of mountings and termination styles. $2 in production qty. with delivery 8 wks. ARO. **Protective Controls, Inc.,** 320 W. Main St., Chartley, MA 02712. Phone (617) 226-1300. **Circle No. 171**



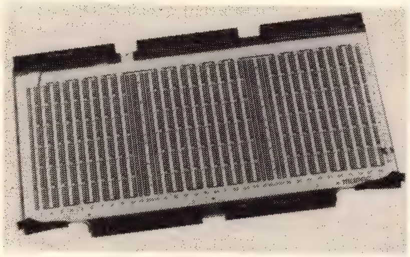
INDICATORS. Each unit in the 249 Series of subminiature indicators is a complete package of light source, housing and lens ready for panel mounting from the rear in a 3/8-in. hole. A choice of LED (red, green or yellow) or neon light sources is offered, with short cylindrical, flat or stovepipe lens shapes. Assemblies that use neon light sources come with or without a built-in resistor. $1 to $1.96 (1000). **Dialight,** 203 Harrison Pl., Brooklyn, NY 11237. Phone (212) 497-7600. **Circle No. 172**

RELAY. Latest addition to the T10 line, this 6-pole Form C relay permits board spacing on 0.6-in. centers and accepts drive directly from logic (TTL, CMOS) IC's. It is available with coil voltages of 6, 12, 24, and 48V dc and 2 contact options: permissive-make contacts rated 0.1 to 3A at 28V dc or 120V ac resistive, or bifurcated contacts rated low level to 1A at 60V dc or 120V ac. Units are rated for 5×10^4 operations at full load. Approx. $4 (100). **Potter & Brumfield,** 200 Richland Creek Dr., Princeton, IN 47671. Phone (812) 386-1000. **Circle No. 173**

SOCKET BOARDS. This series of wire-wrappable assemblies is compatible with DEC's PDP/8 and PDP/11 minicomputers. The compatibility results from the boards' single-sided construction—wrappable pins and sockets on the same side. The panels allow center-to-center board spacing as close as 0.5 in., and each 16-position socket is provided with 0.25-in. square pins long enough to permit 2- or 3-level top side solderless wiring. $50 to $100, with delivery 4 to 6 wks. ARO. **Garry Mfg. Co.,** 1010 Jersey Ave., New Brunswick, NJ 08902. Phone (201) 545-2424. **Circle No. 174**



DISPLAY SOCKETS. Series 902-14 or -16 sockets accept 14- and 16-pin alphanumeric-display modules and hold them at 45°, 60° or 90° to the board. They mount as close as 0.4 in. on center and have provision for running a tie-rod through them for gang mounting. Construction includes a glass-filled nylon socket, a glass-epoxy pc-board element with tin-plated circuitry, beryllium copper, gold-over-nickel plated contacts and solder-coated, phosphor-bronze terminals. $1 to $2. **Garry Mfg. Co.,** 1010 Jersey Ave., New Brunswick, NJ 08902. Phone (201) 545-2424.
Circle No. 175



SOCKET PANELS. The 326 Series of wire-wrappable boards handles up to 2000 IC's in any mix of 14-, 16-, 18-, 22-, 24-, 28-, 36-, 40- and 42-pin packages. Their high I/O capability (540 pins) enhances logic-requirement subdividing with no sacrifice in electrical or mechanical integrity. Multiple voltage planes (3) let the panels accommodate µP's, RAM's, ROM's and other MSI/LSI IC's. $342 (10). **Mupac Corp.,** 646 Summer St., Brockton, MA 02402. Phone (617) 588-6110. **Circle No. 176**

LED MOUNTS. CLIPLITE™ devices eliminate the 3 biggest problems with discrete LED's: viewing angle, brightness and complex installation. This 1-piece mounting system snaps into a 1/4-in. panel hole with slight finger pressure. Striated lines and fresnel rings, combined with the use of transparent butyrate plastic, result in a 6× increase in brilliance over a 180° viewing angle using any narrow-beam T-1-3/4 LED. Units come in red, green and amber. 10¢(OEM qty.). **Visual Communications Co.,** Box 986, El Segundo, CA 90245. Phone (213) 822-4727. **Circle No. 177**

HEAT SINK. Designed to meet most medium-power requirements, Model 4005 is fabricated from extruded aluminum. It is available in a black finish, and comes in 1.5- or 3-in. lengths. An elevated device-mounting area permits both top and bottom fins. Although efficient in a natural convection mode, Model 4005 performs best in a moderate air flow. Units can be ordered with any standard hole pattern. $1.25 (250). **AHAM,** 968 W. Foothill Blvd., Azusa, CA 91702. Phone (213) 334-5135.
Circle No. 178

TRIMMERS. Developed to satisfy general-purpose applications, Series 850 cermet trimmers feature a brush wiper contact that ensures low noise and excellent settability. These trimmers offer high resolution, ±100 ppm/°C TC's, and a standard resistance value range of 10Ω to 2 MΩ. Rated for 0.5W at 70°C, the units are available in both base- and side-pin models and have an operating temp. range of −55 to +150°C. 99¢ (1000). **Weston Components,** Kennedy Blvd., Archbald, PA 18403. Phone (717) 876-1500. **Circle No. 179**

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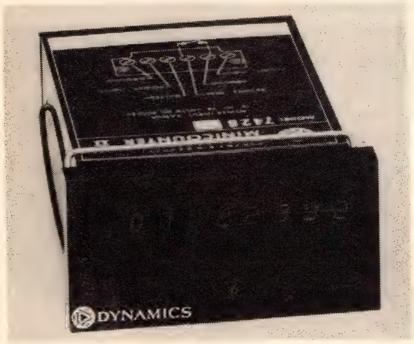
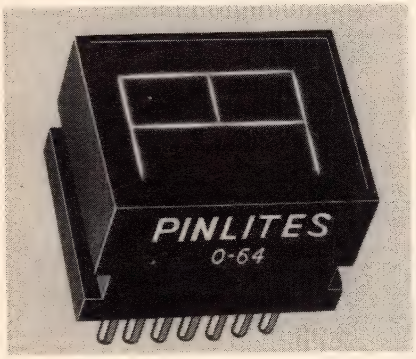
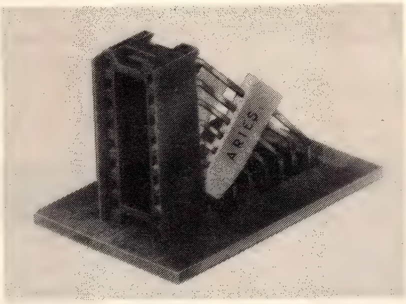


COUNTER. Model 7428 Minicounter II features solid-state reliability, an 8-digit LED display, silent operation and counting speeds to 12,000 counts/min. The unit comes with or without reset, and provides a battery connection that retains count during power outage. Trigger level is 3 to 100V with a min. pulse width of 2.5 msec. Screw terminals provide connection convenience. $49. **Dynamics Electronic Products,** 9001 Fullbright Ave., Chatsworth, CA 91311. Phone (213) 998-0121. **Circle No. 180**

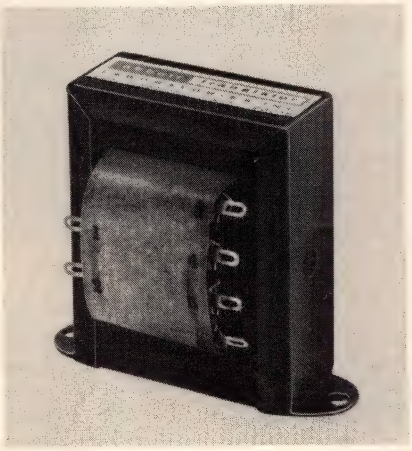


DISPLAYS. Pinlites Model 0-64 is a directly viewed, 4V, 16-segment, incandescent alphanumeric display with a 5/16-in. character height. It offers 9000 fL of light output, giving contrast ratios to 7:1 (filtered) in 10,000 fc's of ambient light. The device comes in a 0.312×0.406×0.375-in. package, draws only 17 mA/segment, can be ac- or dc-driven and lends itself to most multiplexing schemes. Also available are 3V (0-63) and 5V (0-65) models. $29 (100). **REFAC Electronics Corp.,** Box 809, Winsted, CT 06098. Phone (203) 379-2731. **Circle No. 181**

SWITCHES utilize a proven difficult-tease switch mechanism. Models MSS-104 (spdt) and MSS-204 (dpdt) provide a 4A, 125V ac rating in a small, fully insulated low-profile case with pc terminals spaced on 0.1-in. centers. Contacts and terminals are supplied in silver with gold flash (optionally available with gold plate). Offered with either top or side actuator levers, the units have a 30,000-operation lifetime. 67¢ (1000) for an spdt model. **Alco Electronic Products, Inc.,** 1551 Osgood St., N. Andover, MA 01845. Phone (617) 685-4371. **Circle No. 182**



DISPLAY SOCKETS. VERTISOCKETS, a full line of 8- to 40-pin sockets for optoelectronic devices, feature mounting angles (to the board) of 0°, 30°, 45°, 60° and 90°. The design gives a firm no-rock mounting and positions easily for soldering. Bifurcated pin/contacts (either gold or tin plated) accept either flat or round leads for positive electrical contact. Sockets for edge-card mounting are also available. 98¢ to $2.85. **Aries Electronics, Inc.,** Box 231, Frenchtown, NJ 08825. Phone (201) 996-4096. **Circle No. 183**



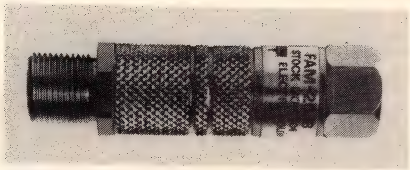
TRANSFORMERS. A 60-Hz industrial device, Model 6B-60 supplies output voltages from 5 to 120V ac at a power level of 60W. With a 115V ac input, output-voltage tolerance is within 5% when measured at full load. The devices have an insulation test spec of 1500V ac, can operate at 80°C max. and are 80 to 90% efficient. These transformers are vacuum-impregnated with a class B insulating varnish. $11.89. **Abbott Transistor Labs., Inc.,** 639 S. Glenwood Pl., Burbank, CA 91506. Phone (213) 841-3630. **Circle No. 184**

SWITCH. An illuminated momentary-action push-button design, the dpdt Type A20267 switch meets all requirements of MIL-S-22885/18-01. It is environmentally sealed, shock and vibration resistant and operates over a range of −55 to +85°C. Designed to maintain stable contact resistance, the switch contacts are rated at 28V dc or 115V ac for 2A resistive, 1.5A inductive and 0.5A lamp load. $11.92. **Control Switch,** 1420 Delmar Dr., Folcroft, PA 19032. Phone (215) 586-7500. **Circle No. 185**

SWITCHES. The unique design of the MR. CLEAN™ miniature slide switches facilitates cleaning and automatic handling while eliminating failures due to residual contamination from wave-soldering processes. Designed specifically for low-energy applications, these units have contacts of hard gold over a nickel barrier and come in spst, spdt, dpdt and Form Z configurations. 52¢ (1000) for a spst version. **Chicago Switch, Inc.,** 2035 Wabansia, Chicago, IL 60647. Phone (312) 489-5500. **Circle No. 186**

TRANSFORMERS. The PC3000 Series of 230/115V dual-primary, 50/60-Hz power transformers fills the need for off-the-shelf transformers for overseas and domestic use. All connections terminate in pc pins, permitting primary-voltage changes to be made on the pc board. Units provide stepdown and isolation from power lines at levels of 1.5, 4.5 and 7.5 VA (6.3 to 115V output). $5.30 (100). **Microtran Co., Inc.,** Box 236, Valley Stream, NY 11582. Phone (516) 561-6050. **Circle No. 187**

SNAP SWITCH. An open design, the S38-20H allows easy insertion in a pc board. Its flexible front-mounting peg lets users assemble the switch by simply plugging it in—no additional hardware is necessary. Measuring 0.658×0.768×0.228 in., this switch is rated for 2A at 250V ac and has an above-the-board mounted height of approx. 1/2 in. $1.05 (2000). **Cherry Electrical Products Corp.,** 3600 Sunset Ave., Waukegan, IL 60085. Phone (312) 689-7702. **Circle No. 188**



ATTENUATORS. Designed for MATV and CATV systems, these economy-priced, 75Ω fixed-attenuator pads work over the 10- to 900-MHz range. Four models—FAM-3, FAM-6, FAM-12 and FAM-20—provide attenuation of 3, 6, 12, and 20 dB, respectively. Input and output return loss ranges from 13 to 30 dB depending on freq. Typ. attenuation is within 0.5 dB for the -3 and -6, and within 0.5 to 2 dB for the -12 and -20. $3.61. **Blonder-Tongue Labs., Inc.,** 1 Jake Brown Rd., Old Bridge, NJ 08857. Phone (201) 679-4000. **Circle No. 189**

MOTORS. This line of low-cogging, iron-core dc motors fits applications where low-speed stability and minimal jitter are important criteria. They come in 2 diameters (1 and 1.5 in.) and with stall-torque ratings ranging to 25 oz-in. Models are available with ball bearings or sintered oilless bearings, and can be supplied with gearheads or ac or dc tachometers. From $7 (OEM qty.) for 1-in. models; $12 for the 1.5-in. size. **Canon USA, Inc.,** 10 Nevada Dr., Lake Success, NY 11040. Phone (516) 488-6700. **Circle No. 190**

SWITCHES. Snap-in and panel-mounting units in the 513 Series of incandescent-illuminated, push-button switches come in round, square and rectangular shapes. Contact arrangements include N.O. or N.C. spst and spdt, in both alternate and momentary actions. Ratings are 125V ac or 30V dc, 3 to 5A resistive. Terminals come in gold-plated brass, contacts in gold-plated coin silver. $3.42 to $6.77 (100). **Dialight Corp.,** 203 Harrison Pl., Brooklyn, NY 11237. Phone (212) 497-7600. **Circle No. 191**

AIRPAX™

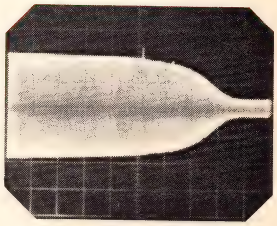
UPG Delay 66 Circuit Protector

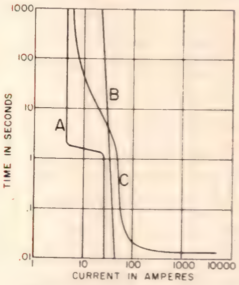
M

Problem Solver!

Problem:

Customer had a ⅓ hp, 115 volt single phase capacitor-run 3450 rpm motor. Running current was 4.6 amperes and starting current was 28 amperes with a start-up time of 1.6 seconds.
He needed overload protection that was faster than that supplied by the internal sensors and a fairly quick dropout in case of a jammed load or stalled rotor.


Start-up Current Envelope
Vertical 7.5 amps rms/div.
Horizontal .2 sec./div.

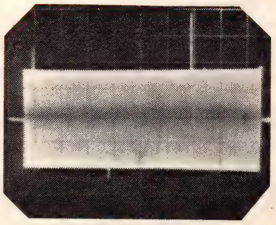


Time vs Current
A — Motor Characteristics
B — 15A Fuse
C — UPG Delay 66, 5A

In order to start the motor without blowing a fuse, he was forced to use a 15 ampere rating. This gave him stalled rotor protection at about 10 seconds, but no overload protection.
The standard long delay magnetic protector required a 7½ amp rating to be able to turn his motor on reliably. This gave him his stalled rotor protection at about 5 seconds, and overload protection at 200%. Still not good enough.

Solution:

The Airpax UPG Delay 66, at 5 amp rating eliminated this problem with turn on . . . locked rotor protection at about 4½ seconds . . . and overload protection at about 150% on nameplate in approximately 400 seconds. This allowed short periods of overload without nuisance tripping. His problem was solved. (Delay 66 is also available in larger Airpax Type 219 and 229 Molded Case units up through 100 amperes.)


Stalled Rotor Trip Out
Vertical 7.5 amps rms/div.
Horizontal .5 sec./div.

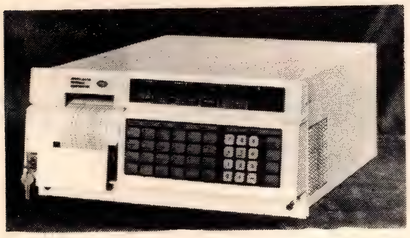
If you have an application with a special protection problem, call Airpax Electronics at Cambridge, Maryland (301-228-4600) or write for literature on Airpax Circuit Protectors and Circuit Breakers.

AIRPAX™

AIRPAX ELECTRONICS
CAMBRIDGE DIVISION
Cambridge, Maryland 21613 • Telex 8-7715 • TWX: 710-865-9655
Other Airpax Divisions:
CONTROLS DIVISION, Ft. Lauderdale, Florida
Instruments for Industry
AMERICAN DATA, Huntsville, Alabama
TV Products

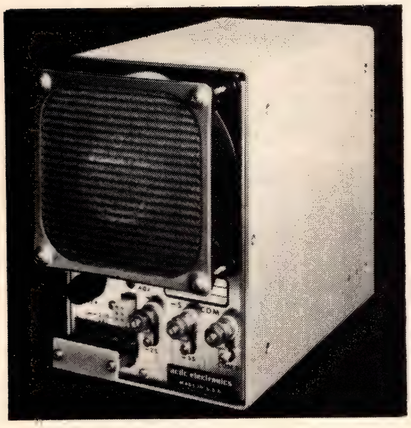
For more information, Circle No. 67

INSTRUMENTATION/POWER SOURCES



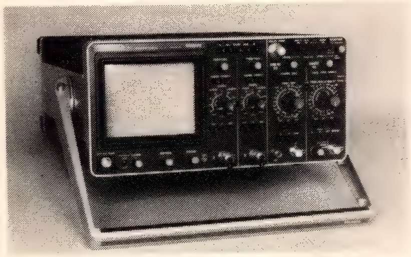
DATALOGGER/MONITOR. The µP-based, field-programmable Model 90 MC was developed by individuals in the sensor/transducer field who are thoroughly familiar with customers' data-acquisition requirements. The device provides a 14-digit display, built-in display of engineering parameters, an integral 21-col. printer, and an internal calendar/clock. Acquisition rates to 100 points/sec and data storage to 1000 points are featured. **Consolidated Controls Corp.,** 15 Durant Ave., Bethel, CT 06801. Phone (203) 743-6721.
Circle No. 192

LINE PRINTER. With this unit, 3 hrs. of TTY operation take only 5 min. of printer-output time. Easily interfaced with most µP systems, it provides print speeds to 2400 lpm (80 col.) or 1400 lpm (132-col. version). Line-to-line spacing is 6/in., while column-to-column spacing is 10/in. $3000. Delivery, 60 days ARO. **Houston Instrument,** 1 Houston Square, Austin, TX 78753. Phone (512) 837-2820.
Circle No. 193

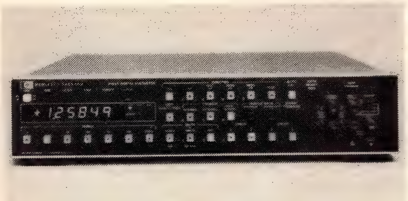


POWER SUPPLY. Providing 5.2V at 16-80A and 2.2V at 0-50A, the JF102 operates from 115/230V ±15%, 47 to 63-Hz single phase. Fan cooling of its compact 5×8×10-1/2-in. case permits full output to 50°C (70% at 71°C). Overload, thermal and overvoltage protection are built in, and the output voltages can be remotely programmed ±5%. $720. **ACDC Electronics,** 401 Jones Rd., Oceanside, CA 92054. Phone (714) 757-1880. **Circle No. 194**

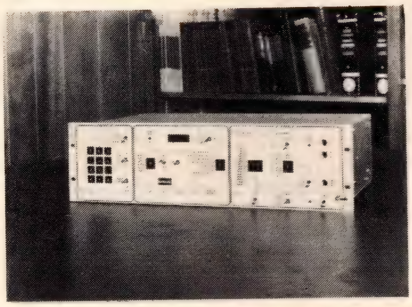
INSTRUMENTATION AMP. Ten of the MX Series-Model B mount in a 7-in. high rack. Each provides wide-band gain accuracy and linearity of 0.01% on all 10 switch-selectable gain ranges. Front-panel controls permit all the gain and bandwidth variations usually available on high-priced units. Gain from unity to 1000, bandwidth to 80 kHz, and gain stability of 0.01% for 6 mo. lead the spec's. $565. **Preston Scientific, Inc.,** 805 E. Cerritos Ave., Anaheim, CA 92805. Phone (714) 776-6400. **Circle No. 195**



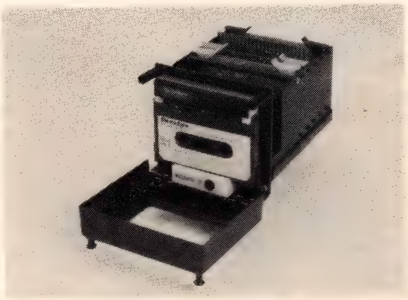
SCOPE. Model PM3265E, a 150-MHz dual-trace portable that weighs only 21 lbs. and draws only 55W, features on-screen display of both main and delayed time base in the alternate mode. This enables both the main time base with the intensified zone and the delayed time base expansion of both traces to be viewed simultaneously. Trace-separation controls allow easy alignment of the resulting 4-trace display. Sensitivity and max. sweep speed are 5 mV and 2 nsec, respectively. $2750. **Philips Test & Measuring Instruments, Inc.,** 400 Crossways Park Dr., Woodbury, NY 11797. Phone (516) 921-8880. **Circle No. 196**



SOPHISTICATED DMM. Using microprocessors for both computation and remote programming, the 6-1/2-digit Model 3455A checks its dc and ohms circuits for accuracy, then makes corrections. It measures dc from 1 µV to 1,000V, true-rms ac from 10 µV to 1000V and resistance from 1 mΩ to 15 MΩ. DC measurements are made at 24 readings/sec with 1-µV sensitivity and accuracy of ±0.0023% at F.S. HP-IB I/O for systems operation is standard. $3200. **Hewlett-Packard Co.,** 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501.
Circle No. 197



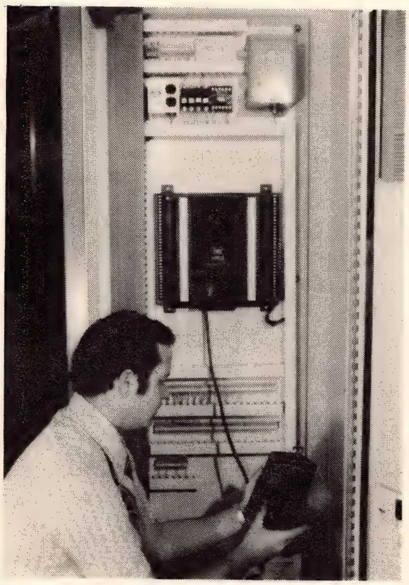
TEST SET. The TC-100, with generator/analyzer/interface sections, performs a wide range of troubleshooting duties to locate and define faults that develop in today's modern data-communications systems. It can simulate and test all components of the data network including communications circuits, modems, terminals and computer ports, as well as test both system hardware and software. **Dynatech Laboratories, Inc.,** 900 Slaters Lane, Alexandria, VA 22314. Phone (703) 548-3889. **Circle No. 198**



DATA LOGGER. The compact (3.8×4.5×7-in.) 3-lb Model 221 features true incremental recording on standard Philips cassettes. One to 16 channels of analog information at a 0 to 10V level may be multiplexed, converted to digital data, buffered and clocked onto a cassette tape at rates to 100 bps. Recording format is complementary NRZ; recording density, 615 bpi. $1375. **Memodyne Corp.,** 385 Elliot St., Newton Upper Falls, MA 02164. Phone (617) 527-6600. **Circle No. 199**

SWITCHER. Delivering 375W total power output from a 10-lb package, Model MM-230 has 3 outputs—5V at 75A, and any 2 of 12V/8A, 15V/8A and 18V/6A. Efficiency reaches 80%, and the unit also features 1% p-p or 50-mV p-p ripple and noise, line regulation of 0.4% and load regulation of 0.4%. Response time is 200 µsec to 1% after a 25% load change. An integral fan allows full rating to 40°C, derated to 60% at 70°C. $530. Delivery, 8-9 wks. ARO. **LH Research, Inc.,** 1821 Langley Ave., Irvine, CA 92714. Phone (714) 546-5279. **Circle No. 200**

PULSE GEN./P.S. Model 151 contains both a digital signal source and a logic power supply. The highly regulated, short-circuit proof supply delivers 1A@ 5V dc, while the signal source provides simultaneous true and complementary TTL-compatible square waves and pulses (10 Hz to 100 kHz) in its astable mode—with manual and remote gating available. Monostable-mode output is single pulses, continuously variable from 5 µsec to 50 msec. $79.50. **Integral Electronics Corp.,** Box 286, Commack, NY 11725. Phone (516) 269-9207 **Circle No. 201**



CONTROLLER. Cost-compatible with relay panels on small applications, the Model 1001 programmable logic controller allows simplified direct entry of relay ladder diagrams without conversion to computer language. This unit also provides the programming and editing features of a CRT; contains an extra "wild-card" that allows flexible programming to add functions; and includes a test panel that enables testing of both program and processor on an individual GO/NO-GO basis. Under $1000. **Struthers-Dunn, Inc.,** Systems Div., Box J, Bettendorf, IA 52722. **Circle No. 202**

STABLE AC SOURCES. The high-power, 3-phase STABILAC™ ac sources compensate for both line and load changes, holding output voltage within ±4% despite simultaneous no-load to full-load shift and −20% to +10% line variations. Ratings run from 9 to 150 kVA, with corresponding prices from $2000 to $12,000. Delivery, 6 wks. ARO. **Frequency Technology, Inc.,** TDC Div., Box 365, Littleton, MA 01460. Phone (617) 456-3374. **Circle No. 203**

PRINTERS. The Swiss-made, 388 Series Precisa pressure-printing OEM units handle up to 16 columns in 2 colors on standard 2.25-in. wide paper rolls. The simplified design permits printing of 5 million lines without servicing. Printing speed is 3 lines/sec, with the motor starting and stopping for each print cycle. $89 (100). **Master Digital Corp.,** 457 Promontory Dr. West, Newport Beach, CA 92660. Phone (714) 675-9674. **Circle No. 204**

Because monitoring by exception is becoming the rule, Doric has built a new breed of process monitor. The Digitrend 240.

The heart of the Digitrend 240 System is a proven 8-bit micro-processor with a memory that can handle up to 1000 input points with 4 individual setpoints per point.

Up to 32 unique measurement functions are featured with scaling, linearizing, offset and engineering units of millivolts, volts, thermocouples, RTDs and current transmitters.

Simple keyboard programming and Control and Output options give you the system capabilities to meet your own unique monitoring needs.

The Digitrend 240 can be operated by pushbutton, control terminal and computer. With output on strip printer, line printer or modem as well as CRT display.

There are a lot of other reasons why the Digitrend 240 is the most exceptional cost/performance process monitor available today. Things like autorange, sub-interval scanning, remote scanning, remote digital displays, and the most versatile alarm package around.

So for a complete description with prices and demonstration, write Doric Scientific, Division of Emerson Electric, 3883 Ruffin Rd., San Diego, CA 92123. Or call toll free (800) 854-2708 — in California (714) 565-4415 collect.

Find out how you can manage your process by exception, and look exceptional in the process.

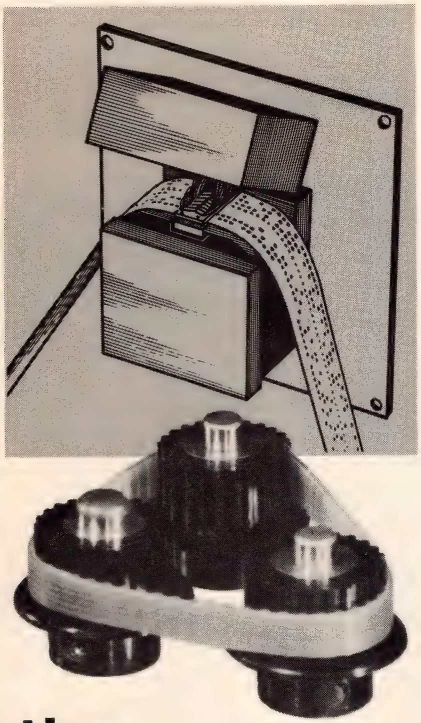
DORIC

INTRODUCING THE DORIC DIGITREND 240 PROCESS MONITOR

It helps you manage
your process
in the most
exceptional
way.

For more information, Circle No. 68

Fenner
Endless Belts



the driving force

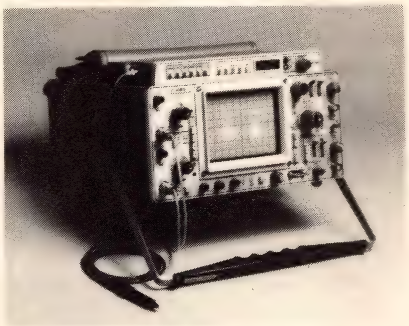
Fenner Posi-Drive "40 DP" Belts are designed for precision performance in sensitive drive applications. These gear tooth belts are ozone-resistant and will operate at pulley speeds up to 20,000 RPM. Available in 64 different sizes, with either Kevlar or Polyester construction, Fenner Posi-Drive Belts offer excellent flexibility to meet your most exacting design requirements.

Fenner

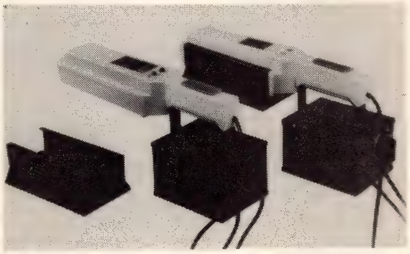
RUSCO BELTING
FENNER AMERICA
400 EAST MAIN STREET
Middletown, Conn. 06457
Tel: 203-346-7721

For more information, Circle No. 69

INSTRUMENTATION/POWER SOURCES

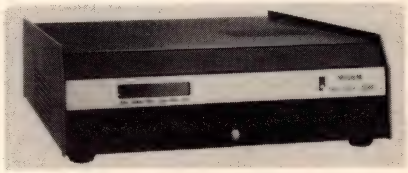


DMM SCOPE OPTION. Model DM44 provides the Tektronix 465, 466, 475 and 475A portable scopes with a means for fast, direct readout of time intervals and frequency; as well as dc-voltage, resistance and temperature measurements. Basic accuracies claimed are 1% for timing, 2% for period, 0.1% for dc V, 0.25% for resistance and ±2° for temperature. $410 (plus scope cost). **Tektronix, Inc.,** Box 500, Beaverton, OR 97077. Phone (503) 644-0161.
Circle No. 205



PROM ERASERS. The S-52T UV lamp, featuring a timer assembly and holding tray, erases up to 16 chips in about 7 min. Similarly, the UVS-54T (that also includes timer assembly and holding tray) erases up to 8 chips in about 14 min. Both are housed in rugged, lightweight CYCOLAC^{R}, and come in 115 or 220V versions. $209 and $99, respectively. **Ultra-Violet Products, Inc.,** 5100 Walnut Grove Ave., San Gabriel, CA 91778. Phone (213) 285-3123. **Circle No. 206**

COUNTER PLUG-IN. When operated with the 8-digit 5300B mainframe, Model 5305B provides sensitivity of 20 mV from 50 Hz to 1300 MHz. A high-resolution mode (for tone measurements to 10 kHz) improves resolution by 1000. Both 50Ω and 1-MΩ inputs have AGC, and a manual attenuation control is provided for the high-frequency channel. An integral power-output jack allows use of the 10855A preamp to boost sensitivity by 10× (22 dB). 5305B, $900; 5300B mainframe, $460; 10855A preamp, $225. **Hewlett-Packard Co.,** 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501. **Circle No. 207**

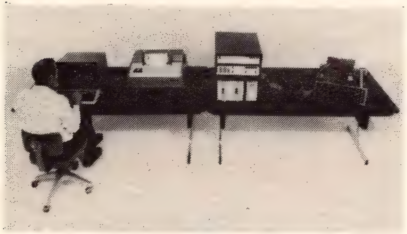


LIMITED-DISTANCE MODEM. The LDM-7296 Data Set transmits and receives nonsynchronous serial data at rates from 0 to 9600 bps, and synchronous data at 1800, 2400, 3600, 4800, 7200 or 9600 bps. It operates simplex or half duplex on a single pair, or full duplex on 2 pairs. A single pc card contains all circuitry. **Syntech Corp.,** 11810 Parklawn Dr., Rockville, MD 20852. Phone (301) 770-0550. **Circle No. 208**

SCANNER. Used in Keithley's System 1, the 703 can be remotely controlled to select 1 or more of 100 channels on a single mainframe. Multiple active channels can be selected simultaneously. A 3-digit readout displays the most recently switched channel, and also provides "error" indicators for improper card insertion and too many activated channels. A rate control varies delay from 5 msec to 5 sec to compensate for settling time in the measurement. $1995. **Keithley Instruments, Inc.,** 28775 Aurora Rd., Cleveland, OH 44139. Phone (216) 248-0400. **Circle No. 209**

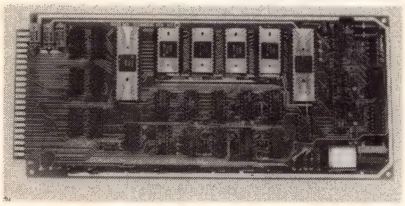
FAN-COOLED SWITCHERS. Both the JF5N120 (5V/120A) and the JF5N150 (5V/150A) are housed in a 5×8×10-1/2-in. case and weigh <20 lb. Their replaceable fan permits full output at 50°C, derating linearly to 70% at 71°C. Designed to meet UL478, the supplies operate from 90-132/180-264V, 47-63 Hz. Both are spec'd at 0.1% regulation and 10-mV rms ripple, and have inherent overvoltage, thermal and reverse-voltage protection. $620 and $695, respectively. **ACDC Electronics,** 401 Jones Rd., Oceanside, CA 92054. Phone (714) 757-1880.
Circle No. 210

COMPUTERS/PERIPHERALS



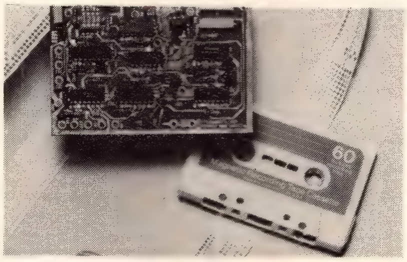
µP DEVELOPMENT SYSTEM. Said to be the first "obsolete proof" µPDS, the TWIN (TestWare Instrument) employs a Signetics 2650 µP as the operational functions-controlling "master," but accepts any other µP as the development "slave." A system typically consists of a development computer with a dual PROM programmer, a dual-drive floppy-disc unit and an operator console. Software alone adapts the system to the µP under investigation. <$10,000. **Signetics,** 811 E. Arques Ave., Sunnyvale, CA 94086. Phone (408) 739-7700. **Circle No. 225**

MICROCOMPUTER. Claimed as the first completely assembled and tested RCA 1802-based µC system available, the UC1800 comes with keyboard, 4-digit hexadecimal display, power supply and case. Other bonuses include: debug software; front-panel interrupt, DMA and I/O flag control; 256 bytes of RAM (expandable to 65.5k); memory-save circuitry; and parallel and serial I/O data-line capability. Full unit assembled, $395; kit, $249.95; CPU board alone, $179. **Infinite Inc.,** Box 906, 151 Center St., Cape Canaveral, FL 32920. Phone (305) 783-9600. **Circle No. 226**

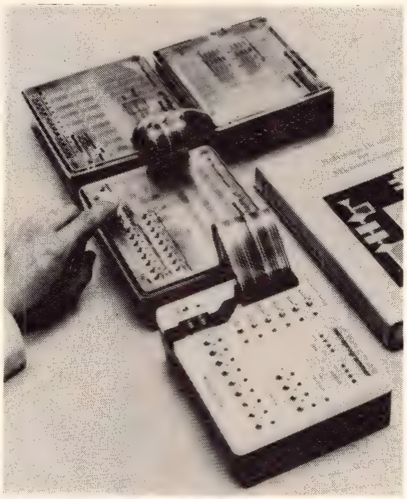


µP SYSTEM. The Gemini-68, a 6800-based stand-alone microprocessing system, consists of a processor board ($245), an 8k RAM board ($245) and an 8k EPROM board ($59.95). The processor board contains a serial I/O socket which uses both RS-232 and 20-mA current loop, and comes with 384 bytes of on-board 6810-1 static RAM, of which 256 bytes are available to the user. All boards fit standard 4-1/2-in. wide card racks. **M & R Enterprises,** Box 61011, Sunnyvale, CA 94088. Phone (408) 738-3772. **Circle No. 227**

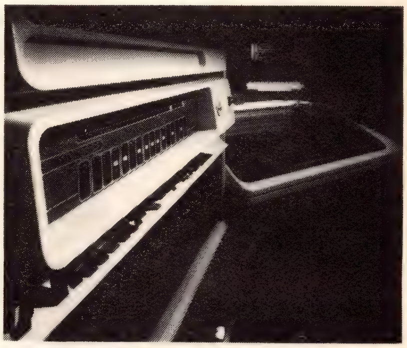
MODEM SWITCHER. The Modem Substitution Switch allows remote substitution of a spare modem for any one of up to 64 on-line modems—at the touch of a button. After repair, the original one can instantly go back on-line. Each control panel handles up to 8 switchers; and each switcher handles 8 on-line modems plus a spare, allowing expansion to 64 modems and 8 spares. **Dynatech Laboratories, Inc.,** 900 Slaters Lane, Alexandria, VA 22314. Phone (703) 548-3889. **Circle No. 228**



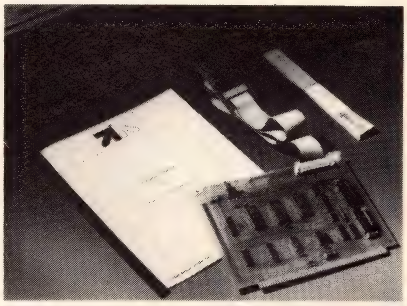
CASSETTE ADAPTER. Model TCC3 allows any serial TTL or MOS output to interface a low-cost audio-cassette player, via FSK (byte standard up to 300 baud), to both a standard RS232 CRT and a 20-mA current-loop TTY. The adapter simultaneously decodes byte-standard FSK data from the audio-cassette players and from 20-mA current loop TTY and RS232 CRT. $129. **Electronic Product Associates, Inc.,** 1157 Vega St., San Diego, CA 92110. Phone (714) 276-8911. **Circle No. 229**



µC LEARNING MODULES. These 3 pre-assembled add-on modules complete the TI Microprogrammer Learning Module user-paced development system introduced last January. Specifically, the LCM-1002 controller ($189.95) provides single-step manual or automatic clock, macroinstruction-load, pc-load and data-register clear functions; the LCM-1003 memory ($189.95), 1024×12 bits of static RAM; and the LCM-1004 I/O ($109.95), four 4-bit I/O ports. **Texas Instruments Inc.,** Box 5012, M/S 308, Dallas, TX 75222. Phone (214) 238-2481. **Circle No. 230**



MINICOMPUTER. The NOVA 3/D, a systems-oriented machine, offers 32k-word MOS memory (128k word max.), a memory-management and protection unit, ease of configurability and high-level software features. Capable of interfacing with a wide range of peripherals, the computer has 12 subassembly slots in a 10.5-in. chassis with an additional 12-slot expansion chassis available. $14,400 and up. **Data General Corp.,** Southboro, MA 01772. Phone (617) 485-9100. **Circle No. 231**

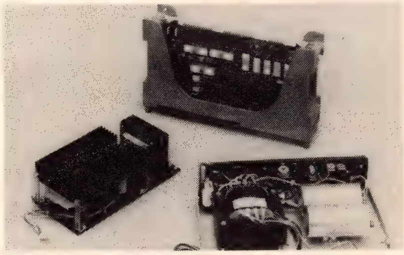


PROGRAMMING SYSTEM. This hardware/software package allows users of the Intel Intellec^R 8/Mod 80 development system to program high-density Model 2704/2708 erasable PROM's. The Model 2730 system installs in <30 min. Included are all software, documentation, 2 boards with ribbon connector, and programming tape required to prepare interface PROM's. No wiring changes are needed. $365. **Texas Microsystems, Inc.,** 3320 Bering Dr., Houston, TX 77057. Phone (713) 789-9820. **Circle No. 232**

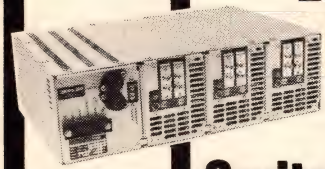
"DUMB" TERMINAL. The ADM-3 is said to be the first full-sized, video-display terminal kit for the computer hobbyist. Its full 24-line, 12-in. screen can display 1920 characters at 80/line. The standard set is 64 ASCII characters generated in a 5×7 dot matrix displayed as upper case, plus punctuation and control. An auxiliary extension RS-232C port for a serial asynchronous ASCII printer is available for hard copy. $875. **Lear Siegler Inc.,** 714 N. Brookhurst St., Anaheim, CA 92803. Phone (714) 774-1010. **Circle No. 233**

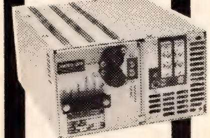
COMPUTER TRAINING SYSTEM. The Com-Tran Ten performs all the functions of large-scale computers, yet fits on a desk for classroom use. Designed to motivate students with "hands-on" learning, this system—which features a variable clock—teaches such concepts as timing, control, memory organization and arithmetic techniques. A large, top-mounted, readout panel continually displays the contents of all registers. $7500. Delivery, 90 days ARO. **Digiac Corp.,** 175 Engineers Rd., Smithtown, NY 11787. Phone (516) 273-8600. **Circle No. 234**

PRINT-ONLY TERMINAL, Model 1201, offers interchangeable, dual-font character sets (uc and lc), quiet thermal printing, small (14×12.5×4.5 in.) physical size and light weight (13 lbs.). Features include 30 characters/sec max. print speed and a full ASCII character set. Available options are: RS-232C, 2-or 4-wire 20-mA current loop or TTL interface; 110-, 150-, 300-, or 1200-baud transmission and more. $1385, parallel; $1505, serial. **Computer Devices, Inc.,** Box 421, Burlington, MA 01803. Phone (617) 273-1550. **Circle No. 235**



μC POWER SUPPLIES. Designated the SBC 630 ($270) and SBC 635 ($460), these supplies convert 115 or 230V ac into regulated ±12 and ±5V dc outputs with system-protective features. Individually, the SBC 630 can power a fully loaded SBC 80/10 single-board computer and has a +26.5V dc output to drive relays and displays; while the SBC 635, a high-current supply, can drive an SBC board as well as 3 memory and I/O-board combinations. **Intel Corp.,** 3065 Bowers Ave., Santa Clara, CA 95051. Phone (408) 246-7501. **Circle No. 236**





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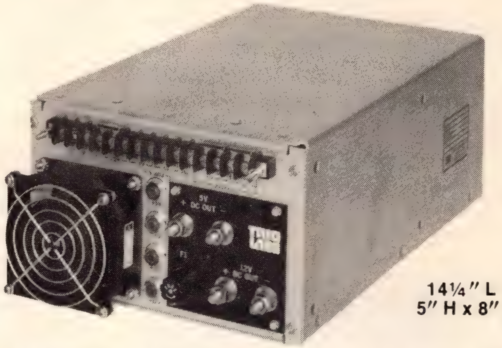

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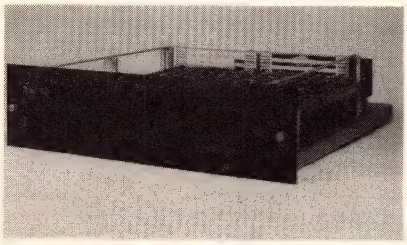
LIGHT PEN. Model LP-400 contains all circuitry in its body, yet provides sensitivity of 2 fL with response time under 300 nsec and TTL compatibility. Touch-activated switching, optional at no extra cost, gives bounceless finger-tip control and lifetime corrosion and wear immunity. A finder light beam insures accurate focusing of the photodetector on a 0.130-in. acceptance circle. $995. **Information Control Corp.,** 9610 Bellanca Ave., Los Angeles, CA 90045. Phone (213) 641-8520. **Circle No. 237**

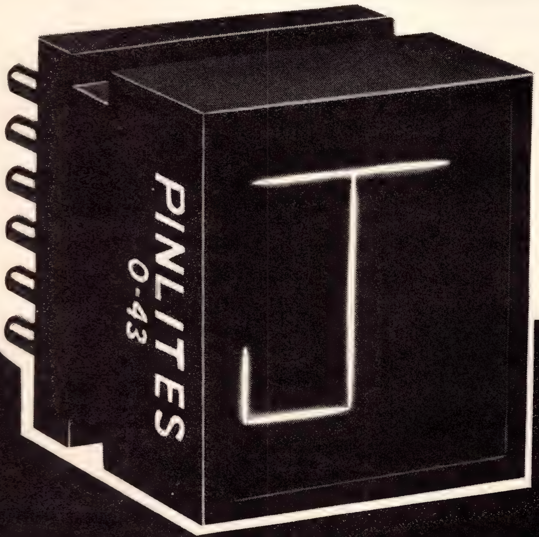


FFT PROCESSOR. Model MFFT-11, a Fast Fourier Transform Processor intended for use with the PDP-11, is a matched combination of a hardware-array processor and signal-analysis software that increases speed in its host minicomputer when performing signal analysis. $6,900. **Elsytec,** 6150 Canoga Ave., Woodland Hills, CA 91364. Phone (213) 884-5200.
Circle No. 238

EXTERNAL µPDS INTERFACE. The M68USE User System Evaluator board replaces the µP module in a Motorola EXORciser™ and allows externally constructed M6800 systems to be connected directly to the EXORciser development system. Thus, all EXbug diagnostic and control features, as well as the system analyzer, can be utilized for system evaluation. A single 40-wire line with connector plugs directly into the external µP's DIP socket. $995. **Motorola Semiconductor Products, Inc.,** Box 20294, Phoenix, AZ 85036. Phone (602) 244-6900. **Circle No. 239**

PROM COPIER. Model 5200 duplicates PROMS in 4 steps, from instant testing of the new PROM to functional testing of the programmed PROM, with pass/fail indications for each step. Safety features include a current-limiting $+V_{CC}$ supply (in case one inadvertantly plugs the PROM in backwards) and short-circuit protected drive lines. The unit accepts Intersil 5600, 03, 04, 05, 10, 23, 24, 25 and 35 PROM's. $1095. **Project Support Engineering,** 750 N. Mary Ave., Sunnyvale, CA 94086. Phone (408) 739-8550.
Circle No. 240

CALCULATOR. A hand-held programmable calculator, the PRO-101, has computer capacity for solving complex problems. The 256 program steps can be divided for a max. of 15 programs at one time, and subroutines can be formed in the execution of the main program and freely used any number of times. If power is turned off, program storage lasts up to 12 mo. Functions include square root, nth power, and percent. $199.50 **Casio, Inc.,** 15 Gardner Rd., Fairfield, NJ 07006. Phone (201) 575-7400.
Circle No. 241



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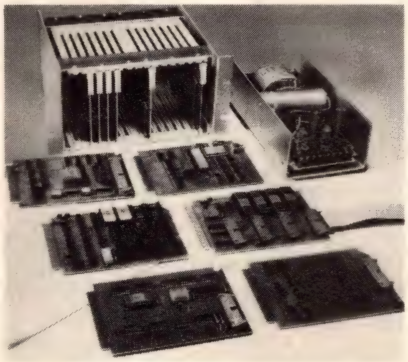
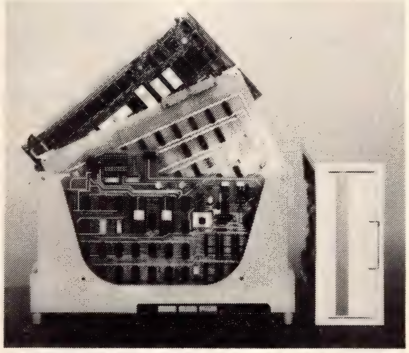
COMPUTERS/PERIPHERALS



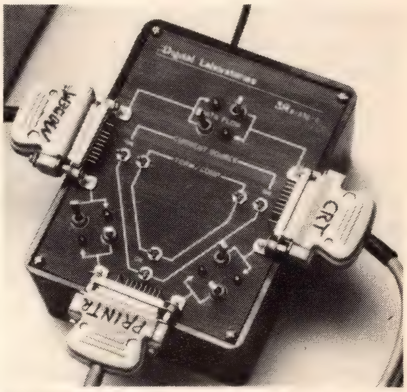
μC SYSTEM. Designed around the MC6800 μP and constructed somewhat like a "CAMAC CRATE," the Omnibyte System consists of a family of functional circuit cards that plug into a bus-oriented back-plane motherboard. Available boards include: CPU ($295), crate controller ($130), 4k ROM/2k RAM ($275), PIA ($260), "Kluge" card (blank except for motherboard interface, $80) and ACIA ($240). The crate itself (Omnibin) costs $225 with power supplies extra. **Omnibyte Corp.,** 900 Jorie Blvd., Oak Brook, IL 60521. Phone (312) 986-1401. **Circle No. 242**



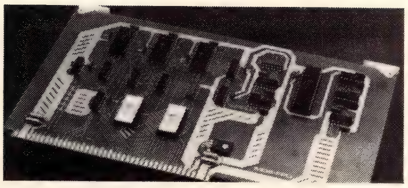
FLOPPY-DISC SYSTEM. Model FF36-1 carries a $1495 price tag, yet includes daisy-chainable disc drive, IBM-compatible controller and all cables and connectors. A Model 360-56 Intel SBC80/10-compatible interface card, containing a software driver, macroassembler and text editor, also comes standard. Software provided includes named variable-length files, auto file create, open and close, multiple merge and delete, auto-disc packing and more. **iCOM Inc.,** 6741 Variel Ave., Canoga Park, CA 91303. Phone (213) 348-1391. **Circle No. 243**

CONTROLLER. Said to be the most powerful programmable controller available, the 1084PC handles up to 10,240 discrete inputs and outputs, and can support up to 80 serial ASCII peripherals. Memory capacity can expand from 2k to 60k in 16-bit equivalent words. The parallel-processing, multiprocessor-type controller is programmed with relay ladder logic. **Modicon Corp.,** Box 83, Shawsheen Village Sta., Andover, MA 01810. Phone (617) 475-4700. **Circle No. 244**

DATA TERMINAL. Controlled by an 8080 μP, the T-3000 prints at speeds to 45 cps, has program-controlled, high-speed tabbing and backward printing, and utilizes a Diablo HyType II graphic-print mechanism. A key feature is the terminal's ability to self-diagnose internal problems. If an error occurs during operation, an error message indicates whether the problem is internal or external. $2875. **Multiterm Corp.,** 2612 Artesia Blvd., Redondo Beach, CA 90278. Phone (213) 376-6975. **Circle No. 245**



JUNCTION UNIT. A connection unit, the 3R permits combining 3 devices such as TTY's, modems, printing terminals, video displays and computers into a common system. The 3R units themselves can connect together, thus expanding indefinitely the number of devices to be combined. Operation is in either the RS-232 or 20-mA current-loop mode. Six more switches establish any combination of the 63 connections. Included is a 3.5-lb power supply. $350. **Digital Labs.,** 600 Pleasant St., Watertown, MA 02172. Phone (617) 924-1680. **Circle No. 246**



μC PLUG-IN. The Floating Point Unit (FPU) improves Intel MDS 800 and SBC 80/10 performance by adding engineering and scientific calculations as callable subroutines. The board extends the 8080 instruction set to include binary to floating-point decimal conversion, all trig functions, logs and powers, the 4 functions (12-digit), coordinate transformation, mean and standard deviation and more. $995. **Cybernetic Micro Systems,** 2460 Embarcadero Way, Palo Alto, CA 94303. Phone (415) 321-0410.
Circle No. 247

CRT TERMINAL. The 8030 display terminal—an 8080-based, firmware-programmed unit—accepts 9600-baud communication speed. Users can program communications functions from the terminal's keyboard, while a 2-pg. refresh memory (3840 characters) permits scrolling through both pages of data. The 15-in. CRT displays up to 1920 characters in a 7×9 dot matrix. This unit is RS232 and ASR/KSR TTY compatible. $2750; delivery, 60 days ARO. **OMRON Corp. of America,** 432 Toyama Dr., Sunnyvale, CA 94086. Phone (408) 734-8400. **Circle No. 248**

SOFTWARE. DAPL, a general-purpose microprogramming language, supports the AMD 2900 and Fairchild 9400 4-bit slice processors (soon available for Motorola 10800 and MMI 6700), allowing selection of any of 4 levels to provide symbolic program representation. A complete variable cross-reference listing (with extensive error detection) and debugging aids are available. Users can choose between hex or binary-object file formats. **Remote Computing Corp.,** 1 Wilshire Bldg., Suite 1400, Los Angeles, CA 90017. Phone (213) 629-2532.
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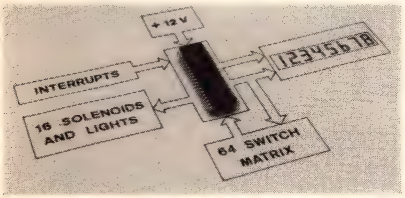
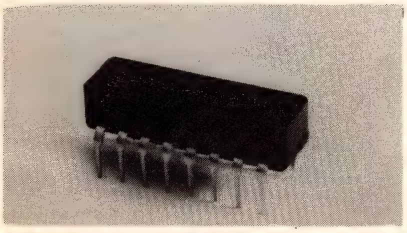
IC'S/SEMICONDUCTORS



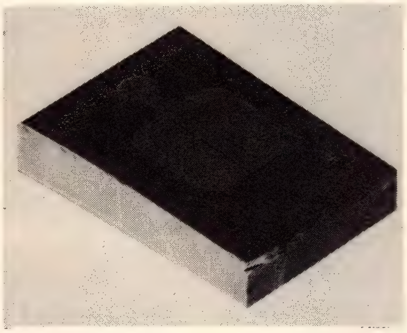
MICROCONTROLLER. Intended for dedicated computing and control applications, the WD/40 stand-alone 40-pin DIP device requires few or no support circuits, since it contains an onboard register file, mask programmable ROM and PLA. This TTL-compatible unit requires only a single supply, and the IC also comes in a 64-pin DIP for development before committing to a mask program. The device addresses 64 signals for inputs. **Western Digital Corp.,** 3128 Red Hill Ave., Box 2180, Newport Beach, CA 92663. Phone (714) 557-3550.
Circle No. 250

16-BIT µP. The TMS 9980, a lower performance version of the 16-bit 9900, is housed in a 40-pin DIP and executes the full 9900 instruction set (including hardware multiply and divide). It features an 8-bit data bus and a 16-bit address bus, making it compatible with byte-oriented memories. The 9980's 9900-type I/O system allows the user to perform DMA, memory-mapped I/O, or the serial I/O port. Both oscillator and clock generator are contained on-chip. **Texas Instruments Inc.,** Box 5012, Dallas, TX 75222. Phone (214) 238-2481.
Circle No. 251



8-BIT DAC. Model 7462 D/A converter operates on a single 5V supply and provides 0-3V analog output voltage. The converter, claimed to be compatible with any 8-bit µP, features ±100 ppm max. error, 100 ppm/°C max. scale-factor drift, 30 ppm/°C max. linearity temperature drift and −55 to 100°C operating temperature range. Max. settling time to 1/2 LSB is 30 nsec. A 16-pin DIP houses the unit. **Optical Electronics Inc.,** Box 11140, Tucson, AZ 85734. Phone (602) 624-8358.
Circle No. 252

PHASE COMPARATOR. Designed for PLL circuits, the 16-pin MC14568B contains a phase comparator, a programmable reference divider and a presettable 4-bit counter. In frequency-synthesizer circuits, the 4-bit counter can be used in the feedback loop by itself, or cascaded with other binary or BCD counters. Two temperature ranges are available: −55 to +125°C and −40 to +85°C. 14568BCP, $2.61; 14568BAL, $3.90 (100). **Motorola Semiconductor Products Inc.,** 3501 Ed Bluestein Blvd., Austin, TX 78721. Phone (512) 928-2600.
Circle No. 253



FET CHIPS. The GaAs AFT2000 eliminates short-term drift and fits low-noise applications up to 15 GHz. Max. available gain at 10 GHz is 10-12 dB, while the typ. noise figure at 10 GHz is 3.5 dB. Since the AFT2000 is similar in physical configuration and S-parameter characteristics to related competitive devices, little or no circuit redesign is required. $95 (10). **Aertech Industries,** 825 Stewart Dr., Sunnyvale, CA 94086. Phone (408) 732-0880. **Circle No. 254**

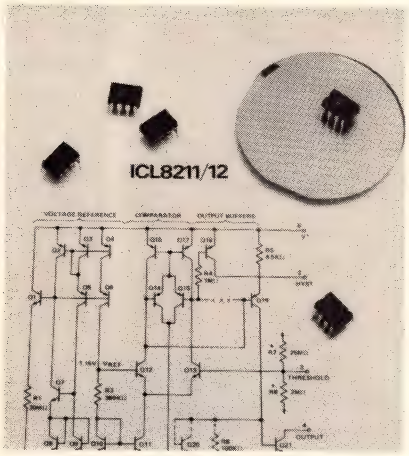
TV GAME CHIP. Six switch-selectable games are provided by the AY-3-8500 video-game IC: tennis, hockey/soccer, squash, pelota, rifle shooting and a rifle game (using a photocell rifle). Key features include: automatic screen scoring and display; selectable bat sizes, angles and ball speeds; and several "realism sounds." V_{cc} equals 6-9.5V (depending on model); supply current, 30 mA. $6 in qty. **General Instrument,** 600 W. John St., Hicksville, NY 11802. Phone (516) 733-3107. **Circle No. 255**

TRIACS. The 2N5806/07/08/09 triacs switch from OFF-state to ON-state for either polarity of applied voltage with positive or negative gate-triggering voltages. These devices, housed in stud packages, are intended for 400-Hz operation with line voltages of 115 and 208V rms. ON-state rms current rating is 25A; repetitive OFF-state voltage ratings, 200, 400, 500 and 600V, respectively. 2N5807, $7.74 (100). **RCA/Solid State Div.,** Rte. 202, Somerville, NJ 08876. Phone (201) 685-6423. **Circle No. 256**

OP AMP. The dual, low-noise XR-4739 is intended for preamplifier use in consumer and industrial signal-processing equipment. It comes in a molded plastic 14-pin DIP and operates over the commercial temperature range (0 to 75° C). The amplifier provides: 76-dB S/N ratio, 125-dB channel separation, 3-MHz unity-gain bandwidth, output short-circuit protection and 0.1% distortion at 8.5V rms output into a 2 kΩ load. **Exar Integrated Systems, Inc.,** 750 Palomar Ave., Sunnyvale, CA 94086. Phone (408) 733-7700. **Circle No. 257**

OP AMPS. Single-supply (3-30V) dual op amp LM158 features large gain-bandwidth, low power and excellent input parameters. The SE532, a dual amp, has single- or dual-supply operation (3-30V), wide common-mode voltages, temperature-compensated bias current and unity gain-crossover frequency. Both are housed in 8-pin TO-99 packages with industry-standard MC1558 pin out. LM158T/883B, $5.53; SE532T/883B, $5.60. **Signetics,** 811 E. Arques Ave., Sunnyvale, CA 94086. Phone (408) 739-7700.
Circle No. 258

LED'S. Model 2SBL, intended to replace incandescent lamps, comes in 3 colors: red, amber and green. At 20 mA (typ.), brightness is 50, 32 and 20 mcd, respectively. Diffused versions are also available. All types can be supplied with built-in resistors for voltages through 48V. Also, for ac operation over 6V, a built-in rectifier is available. Optimum current should be limited to 20 mA for max. life. BX28H (28V, 18 mA), $1.59 (100). **Data Display Products,** Box 91072, Los Angeles, CA 90009. Phone (213) 641-1232. **Circle No. 259**



VOLTAGE DETECTORS. The ICL8211/12 are settable detectors that measure between 2 and 30V. 8211 (8212) output goes ON (OFF) when voltage falls below (rises above) the programmed level. Both devices maintain constant supply currents, 20 μA (typ.), and during the ON state, the 8211 output current-limits to 7 mA to directly drive LED's. These units are available in an 8-pin mini-DIP or TO-99 package. $1.50 (100). **Intersil, Inc.,** 10900 N. Tantau Ave., Cupertino, CA 95014. Phone (408) 996-5000.

Circle No. 260

LINE DRIVER. The 55/75112 dual high-current line driver (alternate sourced by Fairchild) features output currents of 18-30 mA and has no line-transient effects during power up or power down when inhibited. The 55112 is available in a 14-pin ceramic DIP or flatpack in military temperature ranges. The commercial version, 75112, comes in 14-pin ceramic or plastic DIP's. Plasitic, $1.88; ceramic, $2.26 (100). **Fairchild Camera and Instrument Corp.,** 464 Ellis St., Mt. View, CA 94042. Phone (415) 962-3816.

Circle No. 261

PULSE CONVERTERS. Models MC14408 and 14409 convert a 4-bit binary input code to a number of serial output pulses corresponding to the value of the input code. These IC's can be used in telephone pulse-dialing applications when combined with the MC14419. The devices are partitioned to allow addition of RAM. Both circuits operate over 3-6V and are available in ceramic or plastic 16-pin DIP's. Plastic, $6.98; ceramic, $9.08 (100). **Motorola Semiconductor Products Inc.,** 3501 Ed Bluestein Blvd., Austin, TX 78721. Phone (512) 928-2600.

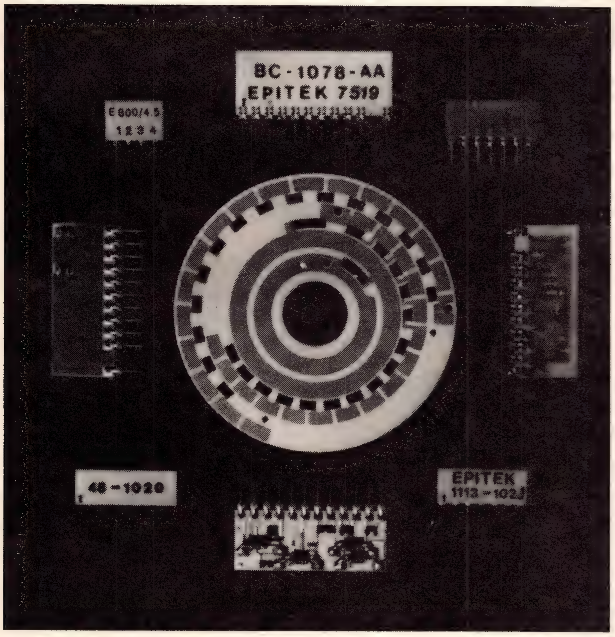
Circle No. 262

POWER UNIT. The BM100-28, an RF power device for broadband, Class AB high-power VHF applications, provides 100W of output power from a 28V supply, and operates over a 70-220 MHz range. This unit is guaranteed to withstand infinite VSWR at all phase angles when operated at full rated CW power and supply voltage. Its wide bandwidth capability results from low-Q input matching. The device is housed in a flange package. $62.40 (100). **Communications Transistor Corp.,** 301 Industrial Way, San Carlos, CA 94070. Phone (415) 592-9390.

Circle No. 263

MOSFET'S. Designed for VHF TV and communications receiver applications, the 3N201/02/03 Series of dual-gate MOSFET's features 0.03-pF (max.) reverse transfer capacitance and diode protection on the gates. The 3N201/02 are, respectively, for VHF amplifier and mixer operation; the 3N203 for IF amp. At 200 MHz the min. common-source power gain is 15, 15 and 20 dB. All are housed in metal, TO-72 packages. 3N201 and 3N202, 65¢; 3N203, 55¢ (100). **Motorola Semiconductor Products Inc.,** Box 20912, Phoenix, AZ 85036. Phone (602) 244-3465.

Circle No. 264



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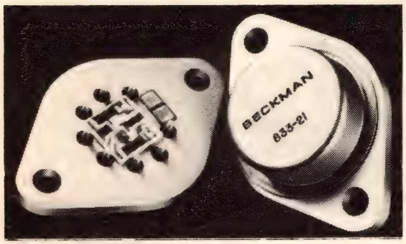

HIGH-POWER OP AMP. Available in a hermetic 8-pin TO-3 package rated at > 20W, Models 833-21 and −21C deliver over 1A output. Features include 15-kHz full-power bandwidth, 100-mW quiescent power (at ±15V), 1-mV input offset voltage, 20-nA input offset current, 3V/μsec slew rate and 100-dB open-loop gain. High-input and low-output impedances lend themselves well to power applications. 833-21 (−55 to +125°C), $39.10; 833-22 (−25 to +85°C), $19.50. **Beckman Instruments, Inc.,** Helipot Div., 2500 Harbor Blvd., Fullerton, CA 92634. Phone (714) 871-4848.
Circle No. 265

LINEAR BANDPASS FILTER. Measuring only 1×2×1/2 in., the voltage-tuned Model VTF-1 covers from <10 Hz to 10 kHz with linearity of 0.02% of F.S. plus 0.1% of the tuned frequency. Externally adjustable to over 250, the Q-factor remains essentially constant—and output varies less than 1/2 dB (at Q=100)—throughout the full range. Control voltage ranges from 0-10V, and the filter furnishes simultaneous in-phase and quadrature outputs. $200. **D-B-Developments,** 7709 Kilbourne Rd., Rome, NY 13440. Phone (315) 339-1265.
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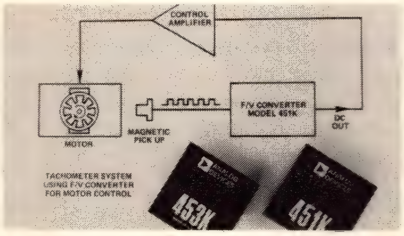

F/V CONVERTERS. Accepting TTL, HNIL, CMOS, sine-wave, square-wave, pulse, and triangle-wave inputs, Model 451 (10 kHz) and Model 453 (100 kHz) provide programmable input threshold, gain, and output offset voltage while supplying 20-mA output current. Three versions of each model are available: both the 451J and 453J feature 0.03% max. nonlinearity and 100 ppm/°C max. gain drift; the "K" versions, 0.015% and 50 ppm/°C; and the "L" versions, 0.008% and 50 ppm/°C. Prices range from $39 to $55. **Analog Devices, Inc.,** Box 280, Norwood, MA 02062. Phone (617) 329-4700.
Circle No. 267

COMPANDING AMP. Because it is linear for small plus and minus inputs and logarithmic for larger ones, the Model 4356 operates with inputs of ±10V and ±10 mA from dc to greater than 20 kHz. Featuring ±3-decade bipolar logging, 40-dB instantaneous audio companding and programmable gain, this unit is well suited for AGC, signal compression and S/N improvement—and easily implements the Sinh^{-1} transfer function. $60. **Teledyne Philbrick,** Allied Dr. at Rte. 128, Dedham, MA 02026. Phone (617) 329-1600.
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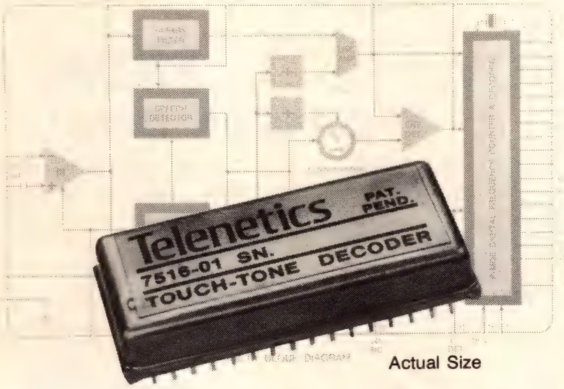

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Telenetics' 7516-01 is a complete Touch-Tone Decoder in a ½ cubic inch, 32 pin DIP. Telephone Standard 2-of-8 tones are received, processed and decoded into discrete 1-of-16 or BCD (plus strobe) outputs. Input signal ranges −22 to +4 dBm with a balanced, capacitively coupled, 50 KΩ impedance. Operating voltage range is 8 to 28V dc (single supply); temperature range −30 to 70°C.

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- 7635 Touch-Tone Keyboards

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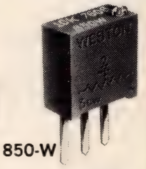
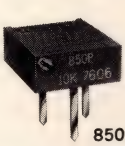


850-W



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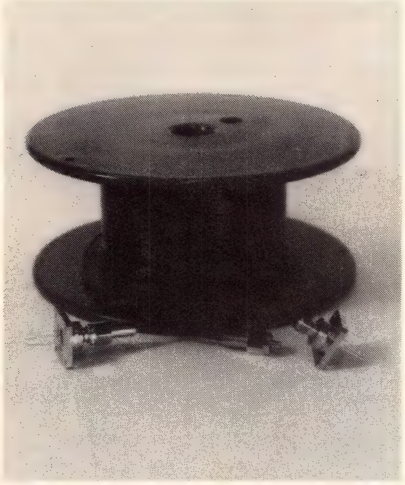
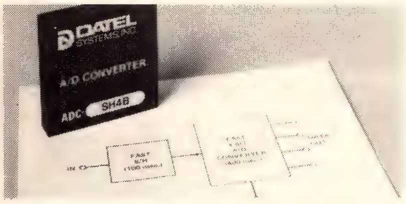


FIBER-OPTIC DATA LINK uses high-speed IR LED's as transmitters and pin photodiodes as receivers. The MDL Series comprises a simple, flexible system with max. frequency range of dc-40 MHz. After mounting in 3-terminal TO-5 headers, these devices are sealed into specially designed SMA or BNC connectors for direct coupling to multifiber cables with minimum insertion loss. A complete system designation requires that users specify the T/R pair, cable type and length, and connector type. **Meret Inc.,** 1815-24th St., Santa Monica, CA 90404. Phone (213) 828-7496.
Circle No. 269

AC LINESENSOR draws operating power from the line being monitored and switches output states if average line voltage rises above the high set point or drops below the low set point. Model 829 comes with either a photo-coupled transistor output stage (829-T), or a mechanical-relay output (829-R) rated for 1A at 26V dc or 0.5A at 115V ac. The unit responds in 100 msec (max.) to a change in average level and in 16 msec (max.) to a line drop-out from 115V ac (±10%). $49. **Calex Mfg. Co., Inc.,** 3305 Vincent Rd., Pleasant Hill, CA 94523. Phone (415) 932-3911.
Circle No. 270



A/D. Suitable for very fast PCM systems, Model ADC-SH4B performs a 4-bit successive approximation in 400 nsec while a self-contained S/H acquires data in 100 nsec; throughput, therefore, can be as fast as 2 MHz. The module contains a zener-diode reference for internal adjustment of accuracy and linearity (±2% max.). Accepting an analog input of 0 to +1V, the unit provides straight binary output coding, positive true. $79. **Datel Systems, Inc.,** 1020 Turnpike St., Canton, MA 02021. Phone (617) 828-8000.
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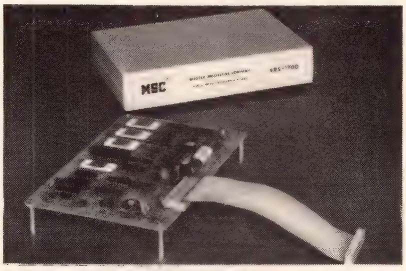
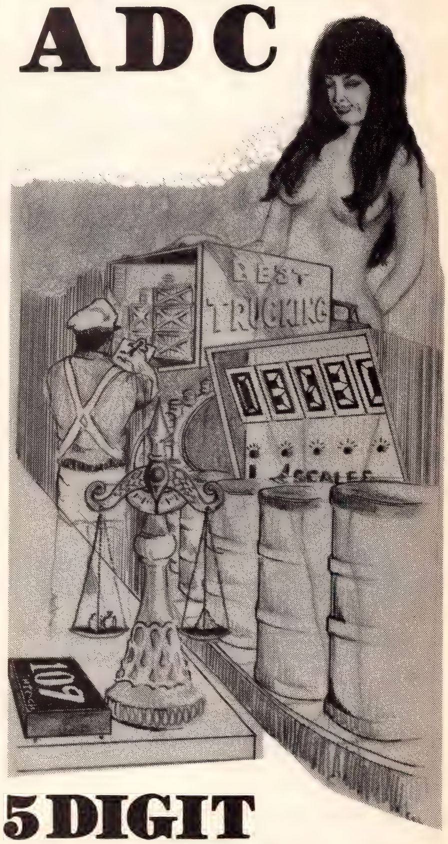


VOICE READOUT SYSTEM consists of 1 circuit board (9×5 in.) with a vocabulary of 1 to 16 words stored in ROM. The Model 1700 reads these words out in any designated pattern to present a desired voice message with audio output at −6 to 0 dBm. "Standard" words include the numbers zero through nine, plus, minus, times, divide and equal. Other (customer-specified) words can be programmed for a one-time charge. The unit draws 2-1/2W max. for 10 words. $500. **Master Specialties Co.,** 1640 Monrovia, Costa Mesa, CA 92627. Phone (714) 642-2427.
Circle No. 272

TEMPERATURE ALARM. Operating on line voltage (115V ±10%, <3W), the Model 8410 early-warning alarm senses temperatures monitored by an external thermocouple. When the temperature approaches within 10% of the high or low setpoint, the output cycles with increasing frequency until the setpoint is reached, where the alarm provides continuous output. Programmable setpoints must lie between −100 and +1300°C, and output contacts on the spdt relay are rated at 120V ac, 1A. $55. **Alnor Instrument Co.,** 7301 N. Caldwell Ave., Niles, IL 60648. Phone (312) 647-7866.
Circle No. 273

the NAKED* ADC



5 DIGIT ACCURACY

The Model 109 yields linearity better than ±0.0025%. With gain and offset errors trimmed out, the absolute accuracy of the Model 109 makes it compatible with resolutions of ±16 bits binary or ±5½ digits BCD.

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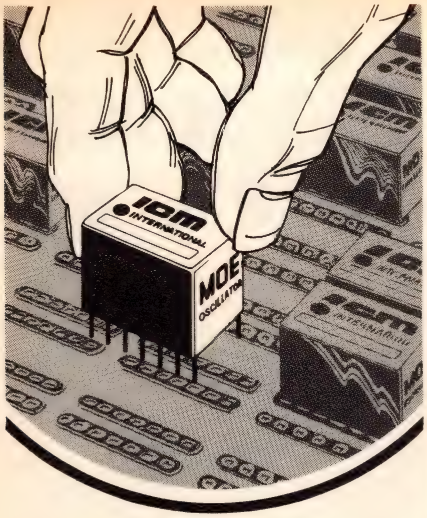

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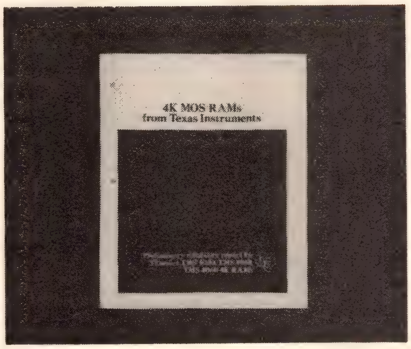
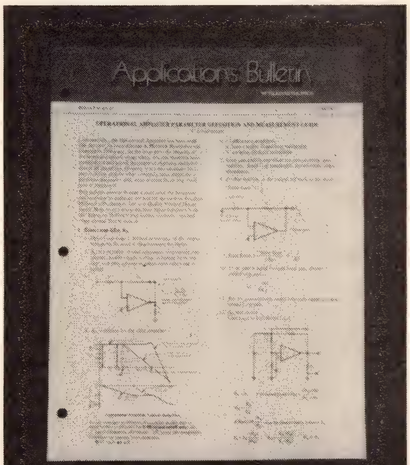
LITERATURE

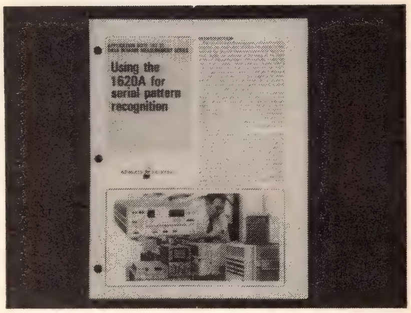

4K MOS RAMs
from Texas Instruments

4k RAM RELIABILITY. This 16-pg. booklet discusses reliability factors of TI's TMS 4030/50/60 Series RAM's that have demonstrated significant improvement over equivalent core-based systems. The report also shows what reliability requirements are needed to meet system MTTF goals, and details environmental tests on both plastic and ceramic packaging. **Texas Instruments, Inc.,** Box 5012, M/S 308, Dallas, TX 75222. **Circle No. 211**

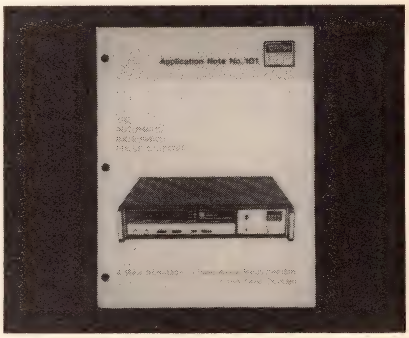
RECTIFIERS. A 2-pg. data sheet describes a line of high-speed switching 2 and 3A silicon rectifiers intended for missile applications. Electrical and mechanical characteristics, absolute max. ratings and a mechanical drawing are included. All units meet MIL-S-19500. **Microsemiconductor Corp.,** 2830 S. Fairview St., Santa Ana, CA 92704. **Circle No. 212**


Applications Bulletin

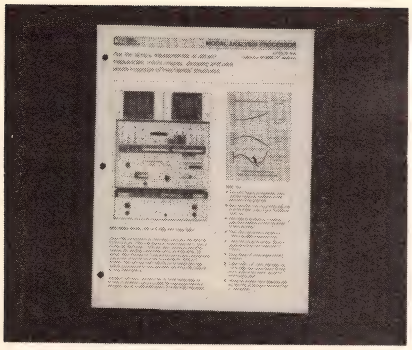
OP AMPS AND POWER SUPPLIES. Often the customer and the manufacturer interpret the same specification differently. To reduce such confusion, 3 parameter and measurement guides detail manufacturer-suggested procedures for op amps (Bulletin AN-23, 8 pg.), modular power supplies (AN-26, 3 pg.), and log amps (AN-27, 3 pg.). **Teledyne Philbrick,** Allied Dr. at Rte. 128, Dedham, MA 02026. **Circle No. 213**


Using the 1620A for serial pattern recognition

PATTERN ANALYZER. Entitled "Using the 1620A for Serial Pattern Recognition," AN 156-10 discusses in detail the capabilities of the HP 1620A, its operating format and its interfacing plans with both oscilloscopes and instruments to be tested. Special sections are devoted to pattern recognition, how the analyzer reads a sample serial code, and case studies. **Hewlett-Packard Co.,** 1501 Page Mill Rd., Palo Alto, CA 94304. **Circle No. 214**


Application Note No. 101

PULSE COUNTER. The 8-pg. app. note 101, "The Automatic Microwave Pulse Counter—A New Approach to Frequency Measurement in the Time Domain," describes previous measurement techniques associated with pulsed RF and time-varying CW signals, and compares them with those obtained by using the Model 451. Sections cover applications, and discuss timing and accuracy considerations associated with automatic pulse-frequency measurement. **EIP Inc.,** 3230 Scott Blvd., Santa Clara, CA 95051. **Circle No. 215**



MODAL ANALYSIS PROCESSOR. A 6-pg. brochure covers "What is Modal Analysis?" "How is a Modal Analysis Conducted?" and "5 Simple Steps for Modal Analysis." It also tells what equipment is needed, giving photos and drawings that illustrate the points discussed. **Nicolet Scientific Corp.,** 245 Livingston St., Northvale, NJ 07647.
Circle No. 216

OCR. The "OCR Application Sketchbook," a 24-pg. publication, focuses on modern low-cost OCR page readers developed specifically for dedicated minicomputer systems. Though not highly technical, the booklet emphasizes those applications for which OCR is profitably used. Technical alternatives to OCR are discussed as well as the economics involved. **Context Corp.,** 4 Ray Ave., Burlington, MA 01803.
Circle No. 217

SCR'S. A series (250PAC and 300PAC) of "hockey-puk" SCR's with surge-current ratings as high as 5000A is described in Data Sheet No. PD-3.044. Complete part numbers, voltage ratings, electrical and mechanical specifications are listed. In addition, 17 graphs portray electrical and thermal characteristics. **International Rectifier,** Semiconductor Div., 233 Kansas St., El Segundo, CA 90245.
Circle No. 218

METRICATION. The revised 11th edition of "Metric Units of Measure and Style Guide" presents basic rules for using metric units, prefixes, and their symbols. Metric practice in this 16-pg. guide is consistent with the International System of Units (SI), or modernized metric system as it is commonly called. $1 each, or 35¢ (100). **U.S. Metric Association, Inc.,** Sugarloaf Star Rte., Boulder, CO 80302. **INQUIRE DIRECT**

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Everything you need to know about Smoke Opacity Monitoring Systems.
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SMOKE MONITORING. "Everything you need to know about Smoke Opacity Monitoring Systems" introduces the technology of opacity monitoring, discusses its basic fundamentals and uses, and outlines the important factors in designing the system best suited to meet specific application requirements. The handbook's 28 pgs. contain a wealth of practical application information. **Dynatron, Inc.,** 57 State St., North Haven, CT 06473.
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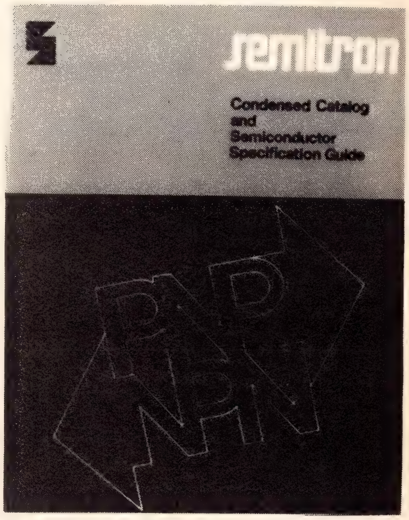

SEMICONDUCTORS. This 2-color, 52-pg. catalog lists the type number, package and technical data for more than 5000 discrete devices in an easy-to-read format. Included are silicon and germanium transistors, silicon rectifiers, stud-mounted silicon power rectifiers, special assemblies and packages, silicon and germanium diodes and thyristors. **Semitronics Corp.,** 64 Commercial St., Freeport, NY 11520.
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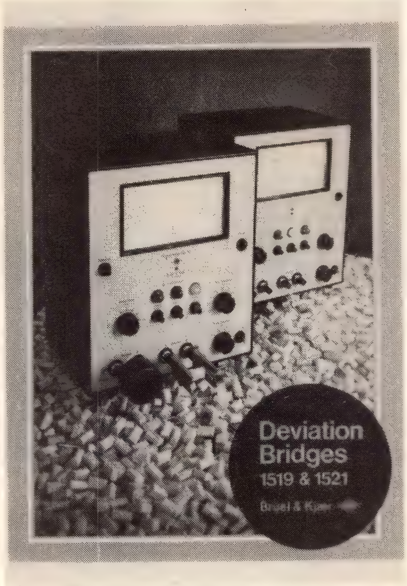

DEVIATION BRIDGES—why you need them, how they operate and where they are useful—plus full specifications on 2 of the company's products are the subjects of a full-color brochure. Both models discussed compare magnitude differences (R, C and L) and phase angle, and have lamps to show tolerance limits. **B & K Instruments, Inc.,** 5111 W. 164th St., Cleveland, OH 44142.

Circle No. 222

MULTIFUNCTION VOLTSENSOR. Along with a detailed discussion of operating theory and a simplified circuit diagram of Model 545, this 8-pg. data sheet outlines available output modes and explains how, with 2 variable trip points, the input may fall into 3 categories: above both, below both, or between. A resistor-sorting application that demonstrates the use of this feature is described. **Calex Mfg. Co., Inc.,** 3305 Vincent Rd., Pleasant Hill, CA 94523.

Circle No. 223

PAPER-TAPE READERS. Basic features of a series of paper-tape readers that combine speeds up to 600 cps with gentle tape handling are enumerated in a 4-pg. booklet. Coverage includes 3 series of readers, each available in reader panel, reader fan-fold and reader/spooler models; plus an individual reader-only unit. **Summit Engineering Corp.,** Box 938, Bozeman, MT 59715.

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2N5004	80	5	TO-59	2N5666	200	3	TO-5
2N5008	80	10	TO-61/I	2N5667	300	3	TO-5
2N5009	80	10	TO-61/I	2N5671	120	30	TO-3
2N5038	90	20	TO-3	2N5672	150	30	TO-3
2N5039	75	20	TO-3	2N6249	225	10	TO-3
2N5153	80	5	TO-39	2N6250	300	10	TO-3
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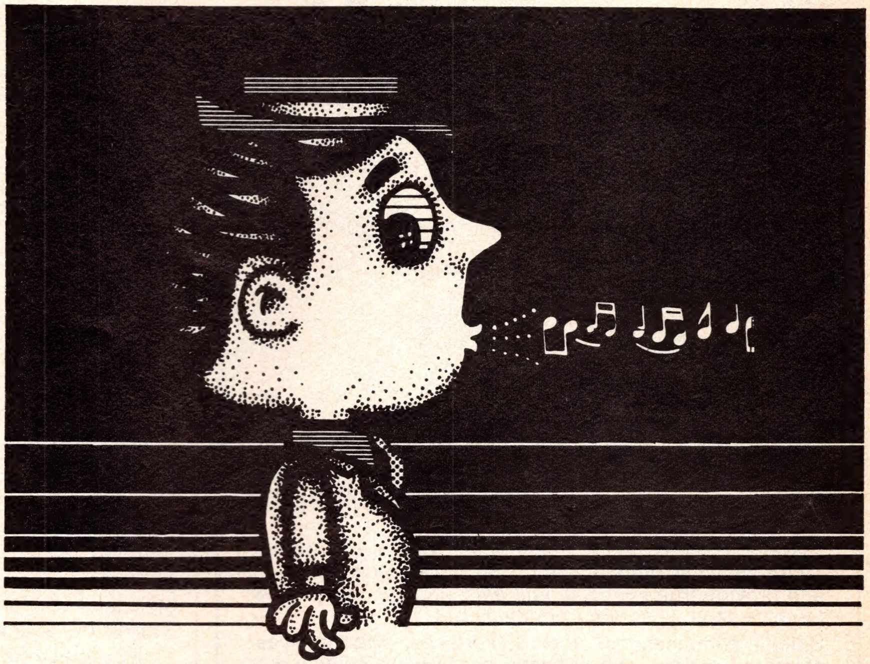

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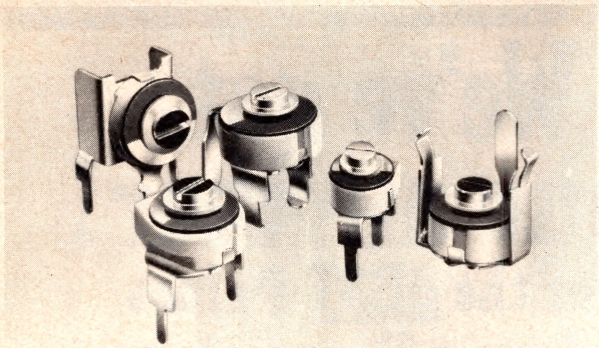

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Darlington	Reflective Sensor Switch	50µA	@	50mA, 5V

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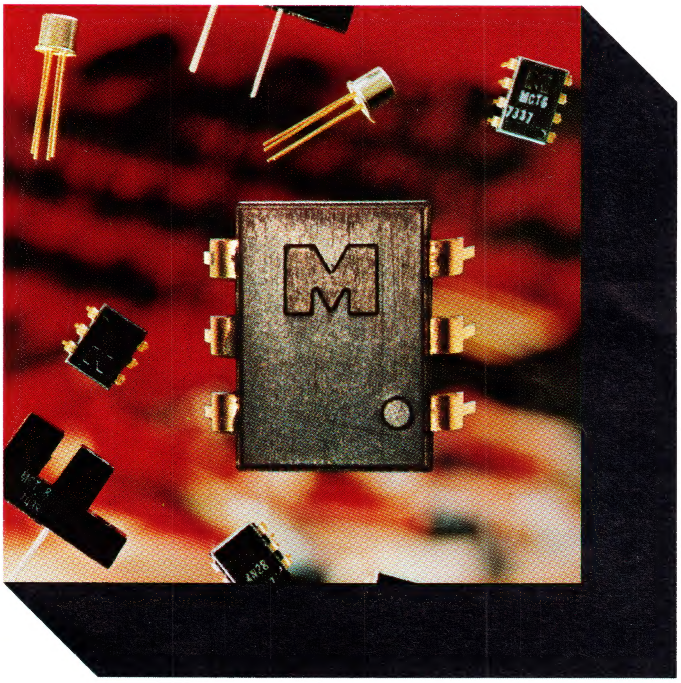

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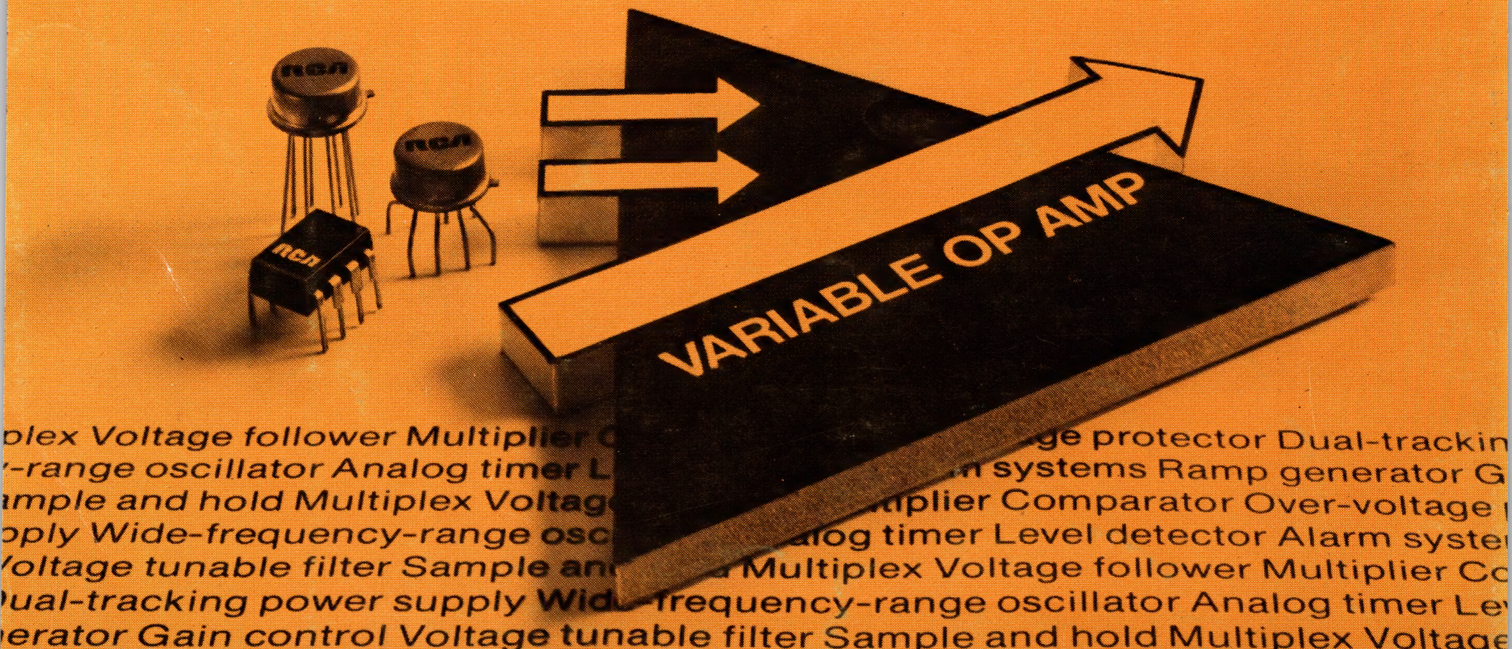
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